Estimating the Effects of Deregulation in the Ontario Wine Retail Market

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Abstract

This paper studies the impact of competition in the Ontario wine market and evaluates the effects of alternative deregulation policies. The wine retail market of Ontario, Canada, is characterized by the coexistence of the government-owned Liquor Control Board of Ontario (LCBO) and two private companies. These private firms can sell only a limited subset of Ontario wines, and they are restricted on the number of stores they can operate. The three firms must charge the same retail prices for the same products, and these prices are set by the government-owned LCBO. Our empirical results build on the estimation of a spatial demand model for differentiated products using a unique dataset from LCBO with information on store sales, prices, and product characteristics for every store and product in this retail chain over a two year period. We take into account that LCBO pricing is designed to maximize its profits subject to four main constraints: (a) all prices are uniform throughout the province; (b) the same markup is applied to all Ontario (Non-Ontario) wines; (c) there is a concern to limit the level of alcohol consumption per capita; and (d) there is a concern to providing incentives to purchase Ontario wines. Given the estimated demand model and LCBO pricing decisions, we identify an implicit tax associated to limiting alcohol consumption, and an implicit subsidy to Ontario wines. We maintain this tax and subsidy in our counterfactual experiments to represent government's concerns other than profit maximization. We obtain estimates of the effects of four counterfactual policies: (i) shutting down retail competition from the two privately-owned retail chains; (ii) changing LCBO pricing policy to allow for markups that reflect the differences in demand elasticities across products; (iii) removing the current restriction on selling non-Ontario wines by the two private wine retailers; and (iv) allowing for price competition between the three retail companies.

Keywords: Competition; Deregulation; Retail markets; Alcohol consumption; Demand of differentiated products; Spatial demand.

JEL codes: L43; L51; L81; H23.

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1 Introduction

In a good number of countries and jurisdictions, the government owns and operates retail liquor stores - either exclusively as a monopolist, or in a highly controlled competitive environment. This is the case in nine Canadian provinces (all except Alberta), eighteen US states,[1] and in Finland, Iceland, Norway, and Sweden, among other jurisdictions. Advocates of this form of regulation often justify it in terms of the social and health externalities associated with alcohol consumption. Furthermore, government attempts to reduce consumption of liquor have been influenced by other considerations: the profits from alcohol sales represent a substantial contribution to the revenue of governments owning liquor stores, and the control of alcohol sales can be seen as an opportunity for protection of domestic producers (Achenson, 1977). Nonetheless, standard arguments for monopolistic inefficiency still apply. A public monopoly may increase prices, limit product variety, and restrict consumption beyond what is required to account for the negative externalities, and it may be less efficient than taxing a more competitive market. In this context, jurisdictions have adopted different types of regulatory environments. To illuminate this complex policy debate, it is important to have empirical studies that evaluate the effects that different hypothetical changes in the regulatory environment would have on government revenue, firms' profits, consumption, and consumer welfare. The main goal of this paper is to provide this type of empirical evaluation for the wine retail market of Ontario, Canada.

The regulatory environment in the wine retail market of Ontario can be described in terms of the following main features. First, the government-owned *Liquor Control Board of Ontario* (LCBO) has the monopoly in the retail sales of foreign wines.[2] Two privately-owned retail companies, Wine Rack (WR) and Wine Shop (WS), sell limited subsets of Ontario wines, and they are restricted on the number of stores they can operate. Second, the three firms (LCBO, WR, and WS) must charge the same retail prices for the same products, and these prices are set by the government-owned LCBO. And third, LCBO pricing consists of fixed markup over wholesale price, and the same markup applies to all Ontario (foreign) wines. In this context, we are interested in evaluating how different forms of deregulation would affect consumer welfare, alcohol consumption, government revenue, and firms' profits. We obtain estimates of the effects of four counterfactual policies: (i)

[1] Following the repeal of Prohibition in 1933, fifteen US states created state monopolies to control the retail distribution of liquor. As of May 2015, the so called Alcoholic Beverage Control (ABC) states were Alabama, Idaho, Iowa, Maine, Maryland, Michigan, Mississippi, Montana, New Hampshire, North Carolina, Ohio, Oregon, Pennsylvania, Utah, Vermont, Virginia, West Virginia, and Wyoming.

[2] In this paper, we refer to any wine that is not considered as Ontario wine as foreign wine. Foreign wine includes not only those from other countries but also include those from the other provinces of Canada. To be considered a wine as Ontario wine, at least 25% of its grapes must come from Ontario.

shutting down Wine Rack and Wine Shop; (ii) relaxing LCBO's uniform markup pricing scheme to allow for markups that reflect the differences in demand elasticities across products; (iii) removing the current restriction on selling foreign wines by the two private wine retailers; and (iv) allowing for price competition between the three retailers.

The deregulations that we evaluate have not been actually implemented in this market, though they have been proposed and discussed in different policy reports.[3] Therefore, our approach is counterfactual and is based on the estimation of a structural model of demand and pricing. A key component of our empirical analysis is the estimation of a model of consumer demand for wine that takes into account both product and store spatial differentiation. We estimate this demand model using a unique dataset from the LCBO with information on store sales, retail and wholesale prices, and product characteristics for every store and product in this retail chain from October 2011 to October 2013 (25 months). While our dataset provides detailed information on sales for every product at every LCBO store, it does not contain information on sales at Wine Rack and Wine Shop stores. We deal with this issue by combining information on the geographic locations of WR and WS stores, the product assortments of these retailers, and consumer demand for these Ontario wines at LCBO stores. Our econometric model takes into account that entry and location of WR and WS stores is not random and could be driven by unobservable demand shocks that are heterogeneous across locations. We account for this selection bias by introducing a selection term and using as an exogenous supply-side exclusion restriction the geographic distribution of WR and WS stores in 2006 (i.e., five years before our sample period in 2011-2013).

We assume that LCBO pricing decisions reflect its goal of maximizing profits subject to the constraint that alcohol consumption per capita does not exceed a certain level. This assumption is consistent with LCBO's mission statement of being a *"socially responsible, customer-focused, and profitable retailer of beverage alcohol"*. We also take into account that LCBO pricing decisions are subject to the self-imposed restriction of charging the same markup to all the products within very wide groups of products, i.e., only two groups in the case of wine: foreign and Ontario wines. Given the estimated demand model, data on wholesale prices, and the predictions of the model on LCBO pricing decisions, we can identify the shadow price or implicit tax (i.e., Lagrange multiplier) associated with the constraint on alcohol consumption per capita. In all our counterfactual experiments, we maintain this implicit tax that represents the government's concern for the health and social

[3] For instance, see the recent report from the Premier's Advisory Council on Government Assets (April, 2015). This is the so called, *Ed Clark's report, where* a team of business and public policy experts advise the government on key assets, including LCBO.

costs related to alcohol consumption.

Most previous empirical studies examining the impact of competition in the alcohol retail market have used a reduced form methodology that consists of aggregate cross section (or panel) comparisons between jurisdictions that have a public monopoly and jurisdictions that have a free entry market (see Zardkoohi and Sheer, 1984, and Nelson, 1990). This approach ignore market heterogeneity and endogeneity of the different competition and regulatory regimes across states, which are serious limitations to do causal inference. In this paper, we use a structural approach for the estimation of consumer demand at the level of individual stores and products. We use the pattern of consumer substitution across products and stores in the estimated model to construct consumer demand and firms' variable profits under counterfactual scenarios for competition and pricing policies. Some specific features of the market structure in the Ontario retail wine industry are particularly helpful in our approach. The existence of some competition between the state-owned firm and two private retailers help us to construct counterfactual scenarios where we shut down this form of competition and where we allow for more competition. In a recent paper, Seim and Waldfogel (2013) also propose and estimate a structural model for the Pennsylvania liquor market and use it to predict the effects of hypothetical competition. They estimate a model of geographic store location to compare the configuration of stores under a monopoly and under a counterfactual free entry market.[4] In contrast, in this paper we take the location of stores as given and concentrate on consumer demand and the effects hypothetical competition in product assortment and prices.

Our approach takes into account LCBO incentives to change its product assortment under some deregulation scenarios. Most previous studies on deregulation of alcohol markets ignore the impact of competition on product assortments carried by different stores, which could have important implications regarding consumers' welfare and efficiency. When an incumbent faces competition from new entrants producing low quality products, it can find profitable to move from selling a wide variety of qualities to concentrate on higher quality products in order to escape competition in the low quality segment (see Gilbert and Matutes, 1993, and Johnson and Myatt, 2003 and 2006, among others). This argument suggests that some forms of deregulation may transform the market from one monopoly to a group of monopolies, a worse alternative from a welfare perspective (Tirole, 1988). This type of outcome seems more likely to occur in the Ontario alcohol market where all

[4] Seim and Waldfogel (2013) find that free entry generates more aggregate consumption but also a geographic reallocation of consumption and welfare, as some rural stores would close and many more urban stores would open. Effectively, the government monopoly in Pennsylvania subsidizes rural consumers at the expense of urban consumers.

firms must charge the same fixed mark-up over the wholesale price for the same product. Pricing restrictions reduce the ability of firms to respond to competitive pressure and could affect the benefits of competition in a market.[5]

Regulation and market structure in the Ontario retail wine industry is characterized by: (i) LCBO has a more than 600 stores and enjoys the monopoly for non-Ontario wines; (ii) WR and WS cannot open new stores without closing their existing stores (no free entry); (iii) there is a substantial asymmetry in terms of the products these chains can sell; and (iv) there is no real price competition. As such, this regulatory context is very different to the hypothetical scenario of a deregulated market considered by Seim and Waldfogel (2013) where atomistic free entry by identical stores replaces the monopoly market (although Seim and Waldfogel also have no price competition). While Seim and Waldfogel's state of competition is conceptually clear, such a complete deregulation may not be entirely realistic considering the history of alcohol deregulation. In fact, the current state of competition in Ontario may reflect the actual history of deregulation in alcohol markets fairly well. While there are some cases where governments fully privatized their publicly owned network of stores immediately (e.g. Alberta in 1992), in general deregulation in this market happens more gradually and over a long period of time, with long periods of asymmetric competition. Historically, the first stage of deregulation has been to allow some other retailers to sell a subset of the products - for example, to allow grocery stores to sell certain types of wine or beer - while maintaining control of a large publicly owned retailer that sells all products.[6] It often takes governments decades to complete the deregulation and the privatization of the publicly owned retailer, if that ever occurs. As such, the Ontario environment makes for an interesting benchmark to evaluate the transition of the market from a monopoly to limited competition - something like the marginal effect of competition in the alcohol retail market.

Our estimates show that shutting down Wine Rack and Wine Shop stores, keeping prices and assortments constant, would reduce the sales of Ontario wine by 50%, increase the sales of foreign wine by 43%, and reduce the total consumption of wine (Ontario and foreign) by 7%. Aggregate consumer surplus would decline by 5%.[7] Interestingly, government revenues are lower under WR

[5] In the fixed price case - assuming that the monopolist initially services the entire market - entry into a monopoly market would create business stealing and duplicated fixed costs, but it would not affect consumer surplus in the market, thereby resulting in lower aggregate welfare as in Mankiw and Whinston (1986) or Berry and Waldfogel (2001).

[6] This was the case for Idaho, Maine, Washington, West Virginia, New Hampshire, and Iowa in the US, and Quebec and British Columbia in Canada. For more detail, see Her et al. (1999).

[7] (**?**) consider the counterfactual of moving from a monopoly to a complete free entry market. Their estimated effects are approximately double of the ones under our more modest deregulation. They find increases in sales and consumer welfare of 14% and 9%, respectively.

and WS competition as compared to the pure monopoly case. By allowing WR and WS to operate in the market, the Ontario government promotes substitution towards Ontario wines sold by these competitors at the expense of public revenues - an effective subsidy to the producers of these specific Ontario wines.

The rest of the paper proceeds as follows. The next section provides some background information on the Ontario wine market. Section 3 presents the data and some descriptive statistics. In section 4, we describe our model. Section 5 deals with estimation and econometric issues. Section 6 presents our empirical results. We summarize and conclude in section 7.

2 Industry and regulation background

LCBO was founded in 1927 as part of the passage of the Ontario Liquor Licence Act.[8] This act established that LCBO was a crown corporation of the provincial government of Ontario, and that its stores were the only legal retailers of liquor and wine.[9] In 1935, each Ontario winery was allowed to operate a single retail store. In the 1970s and 1980s, the Ontario government encouraged larger and more reputable vintners to acquire smaller wineries. The consolidating vintners were allowed to hold on the retail store licenses of the wineries they purchased. The consolidation process ended in 1987 and generated two multi-store vintners: VinCor, with store licences under the brand name "The Wine Rack"; and Andrew Peller, with licences under the brand name "The Wine Shop". They are publicly traded companies.[10]

Today, the wine retail industry in Ontario is effectively a triopoly - consisting of approximately 640 LCBO stores, 164 Wine Rack stores, and 100 Wine Shop stores. There are also about 70 independent wine stores that are owned by other vintners, but they are located in the vineyards of the vintners, which are geographically constrained to two relatively small areas in Ontario - the Niagara peninsula, and Prince Edward County. As such, they provide marginal competition at best to the three chains of wine stores which are widely geographically distributed across Ontario. In this paper, we choose to ignore these small single-store firms.[11]

[8] The Ontario Liquor Licence Act replaced the Ontario Temperance Act of 1918, which banned alcohol sales in the province.

[9] The act also created a consortium of beer manufacturers to commercially retail beer as another centralized chain called "The Beer Store".

[10] VinCor is owned by the American alcohol distributor and manufacturer Constellation Brands, and Andrew Peller is independent.

[11] There are also many bars and restaurants across Ontario that sell wine by the bottle. However, they would probably only directly compete with the LCBO or the two competitor chains under very specific circumstances. For the intent of private consumption, consumers are much more likely to go to a retail store than a bar or a restaurant. We ignore all such establishments in this paper.

Despite its government ownership, LCBO is a profit maximizing company. Indeed, part of its mandate, as described in its governing act is to "[generate] maximum profits to fund government programs and priorities."[12] That said, another part of its mandate is to *"promot[e] social responsibility in the sale and consumption of beverage alcohol"*.

LCBO and its competitors are subject to substantial pricing restrictions. On a given day, prices must be the same across all stores in all markets for a given store-keeping-unit (SKU). There is no price variation across the LCBO and its competitors, for a given variety that they both sell.[13] Retail prices are determined on a fixed markup over the wholesale price fixed by wine distributors. Furthermore, the percentage markup applies to all the SKUs within broadly defined categories. In particular, in our sample period, all Ontario wines have a 65.5% markup, and all foreign wines have 71.5% markup, in addition to other levies.[14] There is also a price floor on wine (6 dollars per 750 ml bottle).

Wine Rack and Wine Shop are subject to some additional restrictions. They are subject to an entry restriction due to the limited number of retail store licenses. As a result, opening a new store requires closing down an existing one. Since 2000, both chains have been operating their maximum number of permitted stores. They are also restricted in the type of products they sell. The intent of the retail license is to showcase the wines of a particular Ontario vineyard. As such, at least 25 percent of the total annual volume of wine sold by the store must be produced by the wineries with which the store is associated.[15] For example, VinCor owns Jackson Triggs and Inniskillin wineries, and Andrew Peller owns Peller Estates and Wayne Gretzky Estates wineries. Furthermore, these private companies are not allowed to sell any foreign wine. As a result, LCBO has market shares of 100 percent in foreign wine, and approximately 60 percent in Ontario wine.

3 Data and descriptive statistics

3.1 Data sources

The data used in this project come from three main sources: (i) LCBO data on sales, prices, and product characteristics at the level of SKU-day-store; (ii) information on the geographic locations of the stores from the three retail chains; and (iii) Census data on consumer socioeconomic

[12] see http://www.lcbo.com/aboutlcbo/todayslcbo.shtml#pricing-policy

[13] Although it is not explicitly stated, if the Wine Rack sells a variety that the LCBO does not sell, it is still nominally under the pricing regulation and are only supposed to mark up their product by 65.5 percent above the wholesale cost. That said, since they are the wholesalers as well, they may implicitly have more pricing freedom.

[14] See the following for more details: http://hellolcbo.com/app/answers/detail/a_id/570/kw/pricing

[15] See the Alcohol and Gaming Commission of Ontario's "Winery Retail Store Information Guide" for more details: http://www.agco.on.ca/pdfs/en/guides/3168_a.pdf

characteristics.

Our data come from LCBO through the *Freedom of Information and Protection of Privacy Act*. The dataset includes information on inventory and sales at day-store-product level, retail prices and markups at week-product level, product characteristics, and stores and warehouses characteristics, including exact geographic locations. The sample period is from October 2nd, 2011 to October 26th, 2013. For the purpose of this paper, we aggregated sales at the SKU-store-month level. For each product, LCBO has assigned a five-digit classification number. The first three digits correspond to the categories used in store displays (e.g., French white wines; Rum), while the entire five digits categorize products at deeper level (e.g., France white wine from South Chardonnay; Flavoured Rum). In this paper, we use data on sales and prices only from wine products.

The second data source is the *Enhanced Points of Interest* (EPOI) data from DMTI Spatial. This dataset records the locations of approximately one million Canadian businesses for 2002-2012. We use these data to determine the locations of stores from Wine Rack and Wine Shop chains at different points in time (see the empirical section for more details about the use of this historical data).

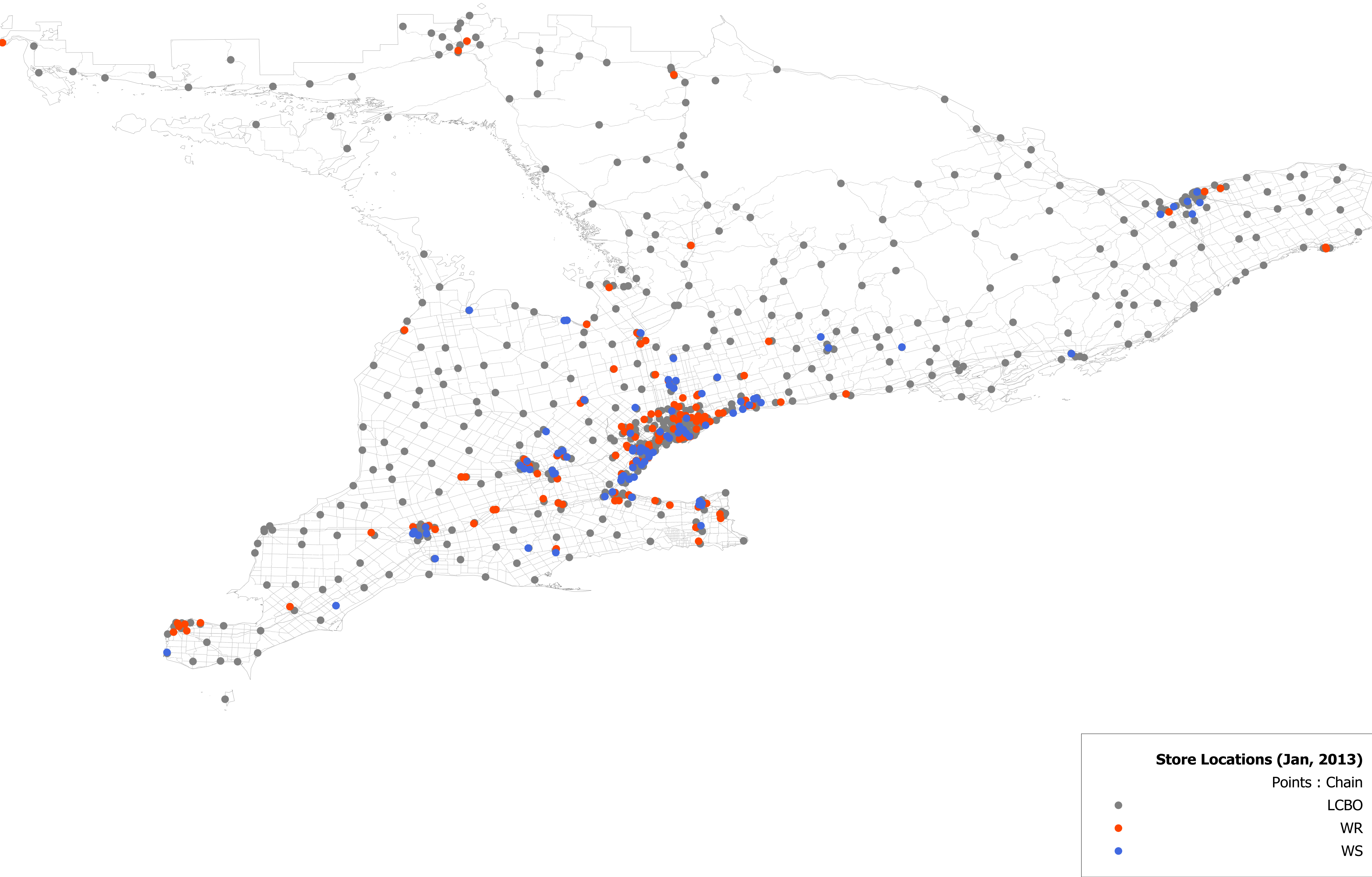
We use data from the 2011 Canadian Census and from the National Household Survey (NHS) to obtain information on market socioeconomic characteristics such as population density, income, house value and median age. The Canadian Census, which only contains data on population and population density was mandatory for all Canadian households. The NHS, which replaced the long form Census in Canada, included around 4.5 million households and was voluntary.[16] Our data on market characteristics are at the Census Subdivision level, or the more disaggregated Census Tract for highly urbanized areas with population density over 8,000 individuals per square km.

In the specification and estimation of our spatial demand model, we need to define consumer "*home addresses*" and the set of stores in the consideration of a consumer. For consumer locations, we assume that all consumers within a census tract (for urban areas) or a census subdivision (for rural areas) are located at the geographic centroid of the tract or subdivision. For consumer consideration sets, we assume that urban consumers are willing to travel as far as 3 km to buy wine, i.e., a consumer consideration set includes all the stores within a 3 km radius around the geographic centroid of her census tract or subdivision. The radius for rural consumers is 10km.[17] Note that the consideration sets of consumers in different census tracts may overlap. Therefore, a store may belong to consideration sets from multiple census tracts.

[16] http://www12.statcan.gc.ca/census-recensement/2011/ref/gazette-eng.cfm

[17] See section 5 for some robustness analysis regarding these distances.

Figure 1 shows the locations of all the stores from the three retail chains. We can see that WR and WS stores (in red and blue, respectively) are mostly concentrated in urban areas such as Toronto, Ottawa, London, and Kitchener-Waterloo, while the location pattern of LCBO stores is much more uniform. Figure 2 provides a closer look at store locations within the Great Toronto Area (GTA). In contrast to the evidence from figure 1, we do not appreciate a substantial difference in the pattern of store locations of the three retail chains in the GTA. It is clear that LCBO has more stores than the private companies, but the locations of their stores seems quite similar. This empirical evidence is consistent with Seim and Waldfogel (2013) who find that the government monopoly in Pennsylvania has an excess of stores in rural areas and too few stores in urban areas relative to the outcomes that maximize profits or aggregate consumer welfare.


Store Locations (Jan, 2013)
Points : Chain
LCBO
WR
WS

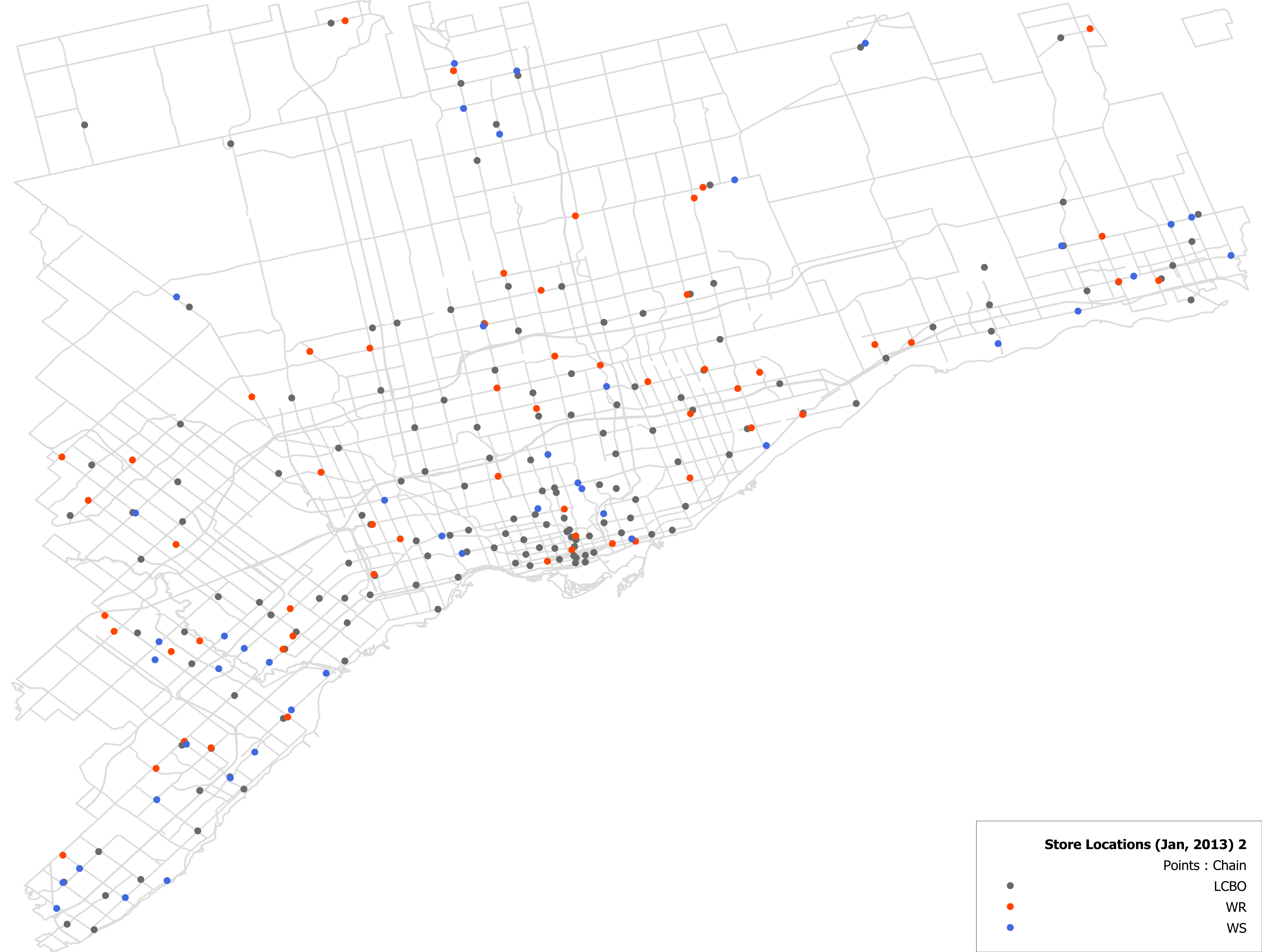

Store Locations (Jan, 2013) 2
Points : Chain
LCBO
WR
WS

Table 1
LCBO Sales, Prices, and Product Characteristics

		Mean	Median	Pctile 10	Pctile 90
Number of SKUs & Monthly Revenue:	Foreign	14,016 SKUs	(CAD 77 million)		
	All Ontario	2,233 SKUs	(CAD 80 million)		
	Wine Rack products sold at LCBO	167 SKUs	(CAD 13 million)		
	Wine Shop products sold at LCBO	116 SKUs	(CAD 10 million)		
Number of stores selling a SKU:	Foreign	47	8	1	153
	All Ontario	173	145	2	417
	Wine Rack products sold at LCBO	259	259	16	512
	Wine Shop products sold at LCBO	287	299	43	466
Price (in CAD per 750 ml bottle):	Foreign	44.30	22.95	12.75	94.00
	All Ontario	18.60	13.05	7.50	30.00
	Wine Rack products sold at LCBO	16.50	9.95	6.55	32.40
	Wine Shop products sold at LCBO	12.51	8.98	6.48	18.95
Sales SKU-month (in 750ml bottle):	Foreign	932	29	1	1,978
	All Ontario	5,400	1,228	5	14,066
	Wine Rack products sold at LCBO	10,669	3,946	42	32,698
	Wine Shop products sold at LCBO	11,900	5,455	164	29,002
Red wine dummy:	Foreign	0.619	1	0	1
	All Ontario	0.417	0	0	1
	Wine Rack products sold at LCBO	0.368	0	0	1
	Wine Shop products sold at LCBO	0.334	0	0	1
White wine dummy:	Foreign	0.254	0	0	1
	All Ontario	0.395	0	0	1
	Wine Rack products sold at LCBO	0.439	0	0	1
	Wine Shop products sold at LCBO	0.441	0	0	1
Alcohol (percent):	Foreign	13.5	13.5	12.0	14.5
	All Ontario	12.5	12.5	11.0	13.9
	Wine Rack products sold at LCBO	12.3	12.5	10.5	13.7
	Wine Shop products sold at LCBO	12.4	12.0	11.3	13.9
Sugar (grames per litre):	Foreign	12.2	5.0	2.0	16.0
	All Ontario	22.3	8.0	2.0	51.0
	Wine Rack products sold at LCBO	25.5	11.0	5.0	72.0
	Wine Shop products sold at LCBO	21.9	9.0	5.0	36.0

Note: Total number of SKUs = 16,249; Number of stores = 634.

3.2 Descriptive statistics

To construct our working sample from LCBO, we select all the wine products with positive sales during the months of October and November, 2011. There are $16,249$ wine products (SKUs) that satisfy this condition. These products represent a total monthly revenue of \$157 millions on average during this sample. A very small number of these products are vintage wines with high prices (up to \$1800 per bottle). Since vintage wines represent a small fraction of total revenue from LCBO wines, and their demand is different to the one of more standard wines, we exclude these products from our working sample. More specifically, we exclude wines with prices above \$600 for a 750 ml bottle.[18] Our working sample includes $16,249$ wine products, 634 LCBO stores, 25 months, and $13,411,155$ SKU-store-month observations with positive sales. The average number of wine products per store is 846 such that this panel dataset is quite unbalanced.

Our measurement unit for quantity sold is a 750 ml bottle.[19] Accordingly, our measurement unit for prices is Canadian dollars per 750 ml bottle. Table 1 presents summary statistics on some characteristics of the wine products in our working sample. We provide these statistics separately for Ontario and Foreign wines, and for the groups of products sold by Wine Rack and by Wine Shop.

There are 2,233 SKUs of Ontario wines and 14,016 of foreign wines. Despite Ontario wines represent only 14% of SKUs, they account for more than half of LCBO monthly revenue from selling wine: CAD 80 million per month (51%). Within the group of Ontario wines, 167 SKUs that belong to Wine Rack, 116 SKUs from Wine Shop, and the remaining $1,950$ SKUs belong to wine manufacturers that do not their own retail stores in Ontario. Products from Wine Rack and Wine Shop are very popular in LCBO stores and they account for monthly revenues of \$13.3 million (8.5% of total revenue) and \$10.1 million (6.4%), respectively. Wine Rack and Wine Shop products are available at a larger number of LCBO stores than foreign wines or than other Ontario wines. They are also less expensive, have a lower proportion of red wines, lower alcohol content, and are sweeter.

[18] In the original dataset, there are 79 wine products with prices above \$600. The median price of these products is \$799, and their aggregate monthly sales are \$172,228 that account for only 0.11% of total LCBO monthly sales from wine products.

[19] Although 90% of the products in the sample are sold in 750 ml bottles, there are also products in other sizes: 1500 ml (3.5% of the products), 375 ml (2.7%), 200 ml (0.5%), and many other sizes with a much smaller representation in terms of number of products. We transform the units of all the products in the equivalent to 750 ml bottles.

3.3 A simple logit demand model

As a way of providing descriptive evidence on consumer demand, we present here OLS estimates of a standard logit demand model. Let q_{jst} be the amount of sales of product j in store s during month t. For the construction of this logit model, we assume that market size in a month is equal to two times LCBO aggregate sales of wine. Let M_t be this measure of market size. Then, the market share of product j at store s is q_{jst}/M_t, and the market share of the outside alternative is $q_{0st} = (M_t - \sum_j q_{jst})/M_t$. According to the logit model of demand:

$$\ln\left(\frac{q_{jst}}{q_{0st}}\right) = X_j\ \beta_x + Z_s\ \beta_z - \alpha\ p_{jt} + \xi_{jst} \tag{1}$$

where X_j and Z_s are vectors of observable product and store characteristics, respectively, other than price; p_{jt} is the price of the product during month t, that is the same across all the stores; and ξ_{jst} represents unobservables (for the researcher) affecting demand.

Table 2 present estimates of equation (1) using OLS in levels, OLS with store fixed effects, and OLS in first differences. All the standard errors are robust of heterocedasticity and clustered over products (SKUs). We also report the own price elasticity implied by the estimated model. In the estimations in levels (either with or without store fixed effects), the estimated pice elasticity is very small (in absolute value): between -0.42 and -0.47. This is a well-known implication of the endogeneity of prices in the estimation of a demand system. Products with characteristics that are attractive to consumers but unobservable to the researcher tend to have both high demand and high prices. The positive correlation between price and these unobservable attributes generate an upward bias in the estimated coefficient for price. The estimation in first differences eliminates from the error term those unobservable attributes that are invariant over time. Under the assumption that the correlation between prices and the error term is lower in the time-series dimension than in the cross-sectional dimension, the endogeneity bias in the estimation in first differences will be smaller then in the estimation in levels. Our estimates are consistent with this explanation. The estimate of the price coefficient increases very substantially in the estimations in first differences, and the implied price elasticity of demand becomes -2.41.

Table 2
Standard Logit Demand Model[1]

Variables	OLS in levels	OLS Store FEs	OLS in Diff	OLS in Diff + Store trends
Price	-0.0211 (0.0013)***	-0.0234 (0.0015)***	-0.1212 (0.0103)***	-0.1212 (0.0103)***
Median Price Elast.[2]	-0.4207 (0.0216)	-0.4665 (0.0247)	-2.4167 (0.1689)	-2.4167 (0.1689)
Red Wine dummy	0.3342 (0.0503)***	0.3448 (0.0544)***	-	-
White Wine dummy	0.1994 (0.0514)***	0.1965 (0.0552)***	-	-
Wine Rack dummy	0.5788 (0.0777)***	0.6833 (0.0812)***	-	-
Wine Shop dummy	0.6309 (0.0919)***	0.7118 (0.0971)***	-	-
Other Ontario dummy	0.1905 (0.0373)***	0.2420 (0.0401)***	-	-
Alcohol	-0.0755 (0.0099)***	-0.0856 (0.0106)***	-	-
Sugar	-0.0003 (0.0006)	0.0001 (0.0006)	-	-
Store Fixed Effects	NO	YES	NO	YES
Store Time trends	NO	NO	NO	YES
Time Fixed Effects	YES	YES	YES	YES
Number of Observations	13,411,155	13,411,155	11,893,999	11,893,999
R-square	0.1350	0.2087	0.0168	0.0173

Note (1): * means $p < 0.05$; ** means $p < 0.01$; *** means $p < 0.001$.
Note (2): This own price elactivity is $\alpha\ p_j(1-s_j)$,where α is the price coefficient, p_j is the price, and s_j is the market share. We evaluate this elasticity at the median price of $19.95 and the median market share of 0.0005.

4 Model

4.1 Basic framework

LCBO sells J wine products using its S retail stores.[20] We index products by $j \in \mathcal{J} \equiv \{1, 2, ..., J\}$ and stores by $s \in \mathcal{S} \equiv \{1, 2, ..., S\}$. The sets $\mathcal{O} \subset \mathcal{J}$ and $\mathcal{F} \subset \mathcal{J}$ represent the subset of wine products that belong to the Ontario and the Foreign groups, respectively. Consumer demand at the product-store level is represented by the demand system $q_{js} = D_{js}(\mathbf{p})$ where $\mathbf{p} = (p_1, p_2, ..., p_J)'$ is the vector of prices for all the products. Prices are the same at every store. Although we include the vector of prices as the only explicit argument of this demand functions, it will be clear below that these functions include also implicitly as arguments the store locations, of LCBO, Wine Rack, and Wine Shop, product characteristics other than prices, and consumer attributes. Section 4.2 describes in detail this demand system. The demand functions $D_{js}(\mathbf{p})$ are twice continuously differentiable.

Despite being one of the largest purchasers of alcohol in the world, LCBO does not negotiate wholesale prices with its suppliers and it is a price taker in its relationship with them. This LCBO's price-taking behavior has been subject to some criticisms because it does not maximize the firm's profit and therefore it represents a transfer from the government to wine manufacturers. See for instance the 2011 Annual Report from the Auditor General of Ontario (McCarter, 2011), or Cohn (2012). However, since the markup is fixed and independent of the wholesale price, it can be argued that LCBO pricing could reduce the double marginalization problem. In this paper we do not examine this interesting topic and we just assume that LCBO takes wholesale prices as given.

Let w_j be the wholesale price of product j.[21] The retail price of wine product j is:

$$p_j = (1 + \tau) \quad ([1 + m_j]\, w_j + \kappa) \tag{2}$$

where τ is an ad valorem sales tax (i.e., the Harmonized Sales Tax, HST), κ is a levy or excise tax on wine, and m_j is the markup over the wholesale price charged by LCBO.[22] After paying the

[20] In the description of this demand model, we take the network of stores and the product assortments of the three retail chains as exogeneously given. However, in the estimation of the demand model, we take into account the econometric endogeneity of store location and assortment decisions. These decisions can be correlated with demand factors that are unobservable to the researcher.

[21] For non-Canadian wines, this wholesale price includes a Federal Excise Tax of \$0.62 per litre and a Federal Import Duty of \$0.0187 per litre. These excise tax and duty apply to the wholesale price, before LCBO markup. LCBO refers to this definition of wholesale as the *Landed Cost*.

[22] The Harmonized Sales Tax (HST) in Ontario is 13% of the Basic Price (i.e., $\tau_{ST} = 0.13$). The levy on wine has three components: a Wine Levy of \$1.62 per litre; a Bottle Levy of \$0.29 per litre; and a Per Contanier Levy of \$0.0893 per bottle. This amounts to a total wine levy of $\kappa = \$1.5218$ per 750 ml bottle (i.e., $1.62 \times 0.75 + 0.29 \times 0.75 + 0.0893$). During our sample period, LCBO markups as a share of Landed Cost were 71.5% for Foreign wines and 65.5% for Ontario wines.

wholesale price to suppliers, and taxes to the Federal and Provincial governments, LCBO variable profit from selling product j is:

$$\pi_j = m_j \ w_j \ \left(\sum_{s=1}^{S} q_{js} \right) \tag{3}$$

LCBO obtains $m_j \ w_j$ dollars per bottle of product j sold in all its stores. We assume that LCBO pricing decisions represent its concern for the maximization of after tax profits subject to the following constraints: (a) the different taxes that imply $p_j = (1+\tau) \left([1+m_j] \, w_j + \kappa \right)$; (b) markups are constant within the product categories of Ontario wines and Foreign wines, respectively; (c) consumption per capita of wine does not exceed a certain amount; and (d) the difference between consumption of Foreign and Ontario wine does not exceed a certain amount. We can represent LCBO pricing as the solution to the following constrained optimization problem:

$$\begin{array}{ll} \text{maximize}_{\{m_j : j \in \mathcal{J}\}} & \Pi = \displaystyle\sum_{j \in \mathcal{J}} m_j \ w_j \left[\sum_{s=1}^{S} D_{js}(\mathbf{p}) \right] \\ & \\ \text{subject to:} & \begin{array}{ll} \text{(a)} & p_j = (1+\tau) \ \ ([1+m_O] \, w_j + \kappa) \\ \text{(b)} & m_j = m_{\mathcal{O}} \text{ for } j \in \mathcal{O}, \text{ and } m_j = m_{\mathcal{F}} \text{ for } j \in \mathcal{F} \\ \text{(c)} & \displaystyle\sum_{j \in \mathcal{J}} \sum_{s=1}^{S} D_{js}(\mathbf{p}) \leq Q^{*(c)} \\ \text{(d)} & \displaystyle\sum_{j \in \mathcal{F}} \sum_{s=1}^{S} D_{js}(\mathbf{p}) - \sum_{j \in \mathcal{O}} \sum_{s=1}^{S} D_{js}(\mathbf{p}) \leq Q^{*(d)} \end{array} \end{array} \tag{4}$$

The Lagrange representation of this constrained optimization problem is:

$$\text{maximize}_{\{m_O, m_F\}} \quad \mathcal{L} = \sum_{j \in \mathcal{O}} \left[m_O \ w_j - \lambda^{(c)} + \lambda^{(d)} \right] \ D_{j\cdot}(\mathbf{p}) + \sum_{j \in F} \left[m_F \ w_j - \lambda^{(c)} - \lambda^{(d)} \right] \ D_{j\cdot}(\mathbf{p}) \tag{5}$$

where $\lambda^{(c)}$ and $\lambda^{(d)}$ are Lagrange multipliers associated to constraints (c) and (d), respectively,

and $D_{j\cdot}(\mathbf{p})$ is the demand for product j aggregated over all the stores, i.e., $D_{j\cdot}(\mathbf{p}) \equiv \sum_{s=1}^{S} D_{js}(\mathbf{p})$. Lagrange multipliers, as shadow prices, are measured in dollars per physical unit of output. As usual, we can interpret the value of these Lagrange multipliers (at the optimal solution) as the marginal increase in profits if we relax marginally (in one physical unit) the constraint. Also, note that we can interpret these Lagrange multipliers as implicit taxes (per bottle).

The solution to this constrained optimization problem implies the following expression for the optimal markup for Ontario wine products (see Appendix A for the derivation):

$$m_{\mathcal{O}} \quad = \quad \frac{1}{\eta_{\mathcal{O}\mathcal{O}} - 1} + \frac{\eta_{\mathcal{O}\mathcal{O}} \ \tau_{\mathcal{O}}}{\eta_{\mathcal{O}\mathcal{O}} - 1} + \frac{\eta_{\mathcal{O}\mathcal{F}} \ \left[\eta_{\mathcal{F}\mathcal{O}} \ \ (m_{\mathcal{O}} - \tau_{\mathcal{O}}) - \left(\frac{W_{\mathcal{F}}}{W_{\mathcal{O}}} \right) (1 + \tau_{\mathcal{F}}) \right]}{(\eta_{\mathcal{O}\mathcal{O}} - 1)(\eta_{\mathcal{F}\mathcal{F}} - 1)} \tag{6}$$

η_{OO}, η_{OF}, η_{FO}, and η_{FF} represent demand elasticities between the two groups of products, Ontario and Foreign wines. Variables $W_F \equiv \sum_{j\in\mathcal{F}} w_j q_j$ and $W_O \equiv \sum_{j\in\mathcal{O}} w_j q_j$ are the aggregate wholesale. The variables τ_O and τ_F represent the Lagrange multipliers percentages of average wholesale prices. More precisely,

$$\tau_O \equiv \frac{\lambda^{(c)} - \lambda^{(d)}}{\overline{w}_O} \quad \text{and} \quad \tau_F \equiv \frac{\lambda^{(c)} + \lambda^{(d)}}{\overline{w}_F} \tag{7}$$

with $\overline{w}_O \equiv \sum_{j\in\mathcal{O}} w_j q_j / Q_{\mathcal{O}}$ and $\overline{w}_F \equiv \sum_{j\in\mathcal{F}} w_j q_j / Q_{\mathcal{F}}$. Equation (6) has an intuitive economic interpretation in terms of three additive terms. The first term, $\frac{1}{\eta_{OO}-1}$, represents the optimal markup for Ontario wines under two conditions: (i) no constraints (c) and (d) on consumption per capita; and (ii) zero cross price elasticity between Ontario and Foreign wines. The second additive component, $\frac{\eta_{OO}\ \tau_O}{\eta_{OO}-1}$, captures the contribution to markup m_O of the implicit tax (subsidy) τ_O (i.e., the contribution of the restriction on per capita consumption, together with the incentives to Ontario wines) under the condition of zero cross price elasticities. For instance, when the elasticity η_{OO} is equal to 3.0 and the implicit tax τ_O is 10%, the first two components are $\frac{1}{\eta_{OO}-1} = 50\%$ and $\frac{\eta_{OO}\ \tau_O}{\eta_{OO}-1} = 15\%$. The third component is related to the cross elasticities between the two groups.

The model is completed with the pricing decisions of suppliers that we describe here as *wine manufacturers*. We index wine manufacturers by f, and use $\mathcal{J}_f$ to represent the set of products from manufacturer f. We assume that these firms compete a la Bertrand, i.e., taking as given the pricing rule of LCBO and the prices of the other manufacturers, each firm chooses the wholesale prices of its products to maximize profits. For any manufacturer f that is not Wine Rack or Wine Shop, its best response prices are determined as the solution of the problem:

$$\begin{array}{ll} \text{maximize}_{\{w_j:\, j\in\mathcal{J}_f\}} & \Pi_f = \sum\limits_{j\in\mathcal{J}_f} (w_j - c_j)\ \ D_j.(\mathbf{p}) \\ \\ \text{subject to:} & \left\{ \begin{array}{l} p_j = (1+\tau_S)\ \ ([1+m_{\mathcal{G}}]\, w_j + \kappa) \quad \text{for } j \in \mathcal{G} \\ \\ \text{For } f\prime \neq f,\ \{w_j :\ j \in \mathcal{J}_{f\prime}\} \text{ is fixed} \end{array} \right. \end{array} \tag{8}$$

where c_j is the unit cost of producing product j. For Wine Rack and Wine Shop, the pricing problem is slightly different because these firms are also retailers. If the their products are sold through LCBO stores, their unit profit is $(w_j - c_j)$. But if they sell their products in their own stores, they obtain a unit profit of $(p_j - c_j)$. Therefore, the pricing decision problem for, say, Wine

Rack, is:

$$
\text{maximize}_{\{w_j:\, j\in\mathcal{J}_{WR}\}} \quad \Pi_{WR} = \sum_{j\in\mathcal{J}_{WR}} (w_j - c_j)\;\; D_{j,LCBO}(\mathbf{p}) + (p_j - c_j)\;\; D_{j,WR}(\mathbf{p})
$$

$$
\text{subject to:} \qquad \begin{cases} p_j = (1+\tau_S)\;\; ([1+m_{\mathcal{G}}]\, w_j + \kappa) \quad \text{for } j \in \mathcal{G} \\ \\ \text{For } f\prime \neq f,\ \{w_j:\ j \in \mathcal{J}_{f\prime}\} \text{ is fixed} \end{cases} \tag{9}
$$

where $D_{j,LCBO}(\mathbf{p}) \equiv \sum_{s\in\mathcal{S}_{LCBO}} D_{js}(\mathbf{p})$ and $D_{j,WR}(\mathbf{p}) \equiv \sum_{s\in\mathcal{S}_{WR}} D_{js}(\mathbf{p})$ represent total sales of product j at LCBO and at WR stores, respectively.

Our approach proceeds as follows. First, we propose and estimate a demand system and use the estimated model to construct the aggregate elasticities $\eta_{\mathcal{O}\mathcal{O}}$, $\eta_{\mathcal{O}\mathcal{F}}$, $\eta_{\mathcal{F}\mathcal{O}}$, and $\eta_{\mathcal{F}\mathcal{F}}$. Second, we use the equations for LCBO optimal markups in (6), together with the observed markups $m_{\mathcal{O}} = 65.5\%$ and $m_{\mathcal{F}} = 71.5\%$, to estimate the implicit taxes $\tau_{\mathcal{O}}$ and $\tau_{\mathcal{F}}$. We can also use the estimated demand system and manufacturers' pricing equations to recover the production costs $\{c_j\}$. Finally, we use all these estimated primitives of the model to obtain equilibrium prices, quantities, profits, and welfare under different counterfactual policy experiments.

4.2 Policy experiments

Counterfactual policy (i). Eliminating competition from privately owned retailers. In this policy experiment we eliminate all the stores from Wine Rack and Wine Shop and evaluate the effects on sales, profits, and consumer welfare. We consider three versions for this experiment: (i.A) keeping all prices constant; (i.B) keeping the same manufacturer wholesale prices but calculating the new LCBO optimal markups; and (i.C) with the new equilibrium wholesale prices and LCBO markups. In contrast to the rest of our counterfactuals, this experiment reduces competition. However, we can interpret this experiment in its reverse form: it provides the effect of going from a pure government monopoly to the limited form of competition introduced by Wine Rack and Wine Shop.

Counterfactual policy (ii). Improving the degree of discrimination in LCBO pricing. Suppose that LCBO pricing allowed for G different groups of products, each with its own markup. In the more flexible form of pricing, every SKU has its own markup. We also consider an intermediate case with different groups of products based on the type of wine (red, white, other), the country or region of origin, and a discrete measure of quality.

Counterfactual policy (iii). Allowing private retail chains to sell all products. In this experiment we consider that Wine Rack and Wine Shop stores can carry the same assortment of Foreign wines as the median LCBO store. As in counterfactual (i), we consider three different versions of this counterfactual: (iii.A) keeping all prices constant; (iii.B) keeping manufacturer wholesale prices but with the new optimal markups; and (iii.C) with new equilibrium wholesale prices and markups.

Counterfactual policy (iv). Price competition between the three retail companies. Finally, we consider an experiment where the three retail chains compete in prices.

In all the policy experiments where we need to calculate new optimal markups, we incorporate the estimated implicit taxes $\tau_{\mathcal{O}}$ and $\tau_{\mathcal{F}}$.

4.3 Consumer demand

We index consumers by i, products by j, and stores by s. In this section, we omit the time subindex t. Following the empirical literature on demand of differentiated products, we consider a discrete choice model of consumer demand. Every consumer has a unit demand. A consumer should decide whether to buy or not a 750 ml bottle of wine, and if he decides to buy it, he should choose the specific product and the store. Let δ_j represent the indirect utility of purchasing product j for the average consumer in the market, at the average store, and without taking into account consumer transportation costs. This average utility δ_j depends on observable product characteristics (X_j, p_j) and on the unobservable error term ξ_j:

$$\delta_j = X_j \ \beta_x - \alpha \ p_j + \xi_j, \tag{10}$$

where β_x is a vector of parameters that represents the marginal utilities of the product characteristics in X_j, and α is the parameter for the marginal utility of income. The total utility for consumer i of buying product j at store s includes also store characteristics (observable and unobservable), consumer transportation costs, and consumer heterogeneity in preferences over products and stores. The specification combines a nested logit structure with a spatial logit model. More specifically,

$$u_{ijs} = \delta_j + \gamma \ d_{is} + Z_s \beta_z + \omega_s + \sigma_1 \ \varepsilon_{ijs}^{(1)} + \sigma_2 \ \varepsilon_{ig(j)s}^{(2)} + \sigma_3 \ \varepsilon_{is}^{(3)} \tag{11}$$

The term $\gamma \ d_{is}$ captures consumer transportation costs, where d_{is} is the distance between store s location and consumer i's home address. The parameter γ is the unit transportation cost. The term $Z_s \beta_z + \omega_s$ represents consumer valuation for store characteristics other than distance. Z_s is a vector of store characteristics that are observable to the researcher, such as dummies for the retail chain (brand name) of the store, i.e., LCBO, WR, or WS. β_z is a vector of parameters. ω_s represents the effect of store characteristics that are unobservable to the researcher but valuable to the average consumer.

The variables $\varepsilon_{ijs}^{(1)}$, $\varepsilon_{ig(j)s}^{(2)}$, and $\varepsilon_{is}^{(3)}$ are all extreme value type 1 random variables that are independent of each other and independently distributed over individuals, products, and stores. $\varepsilon_{is}^{(3)}$ represents consumer idiosyncratic tastes over stores. $\varepsilon_{ig(j)s}^{(2)}$ captures consumer heterogeneity over groups of products. We partition the J products into G mutually exclusive groups of products. We index groups by $g \in \{1, 2, ..., G\}$. $g(j)$ represents the that product j belongs to. In this paper, a natural classification of products would be into four groups: Wine Rack products ($g = WR$), Wine Shop products ($g = WS$), Rest of Ontario wines ($g = RO$), and Foreign wines products ($g = F$). We have estimated the demand model under this group partition but also under finer partitions. The variable $\varepsilon_{ijs}^{(1)}$ represents consumer heterogeneous tastes over products within a group. σ_1, σ_2, and σ_3 are parameters that represent the degree of consumer taste heterogeneity between stores (i.e., parameter σ_3), between groups of products (i.e., σ_2) and between products within the same group (i.e., σ_1).

A consumer chooses the combination product-store (j, s) that maximizes its utility. We use index $(j, s) = 0$ to represent the choice of not buying a bottle of wine. The aggregation of individual consumer choices over all the consumers in the market provides the aggregate demand for every product-store (j, s), i.e., q_{js}. There are L consumer addresses in the market, that we index by $\ell \in \{1, 2, ..., L\}$. H_ℓ represents market size in address ℓ. For a consumer living in address ℓ, variable $d_{\ell s}$ represents his geographic distance to store s. According to the model:

$$q_{js} = \sum_{\ell=1}^{L} H_\ell \; \mathbb{P}_{\ell js} \tag{12}$$

where $\mathbb{P}_{\ell js}$ is the probability that a consumer living in address ℓ decides to buy product j at store s. The model also implies that this probability has the following nested structure:

$$\mathbb{P}_{\ell js} = \mathbb{P}_{\ell s} \; \mathbb{P}_{g(j)|s} \; \mathbb{P}_{j|s,g(j)} \tag{13}$$

where $\mathbb{P}_{\ell s}$ is the probability that a consumer living in address ℓ decides to patronize store s; $\mathbb{P}_{g(j)|s}$ is the probability that a consumer buys a good in group $g(j)$ given that he visits store s; and $\mathbb{P}_{j|s,g(j)}$ is the probability of buying good j conditional on the choice of group $g(j)$ and store s. The assumption of independent extreme value unobservables implies that these three conditional probabilities have a multinomial logit structure. The within-group choice probabilities are:

$$\mathbb{P}_{j|s,g(j)} = \frac{a_{js} \;\; \exp\left\{\frac{\delta_j}{\sigma_1}\right\}}{\sum_{k \in g(j)} a_{ks} \;\; \exp\left\{\frac{\delta_k}{\sigma_1}\right\}} \tag{14}$$

where $a_{js} \in \{0, 1\}$ is a binary variable that represents the event "product j is in the assortment of products in store s", such that the vector $(a_{1s}, a_{2s}, ..., a_{Js})$ represents the assortment of store s.

The between-group choice probabilities are:

$$\mathbb{P}_{g|s} = \frac{\exp\left\{\frac{\sigma_1}{\sigma_2}\ I_{gs}^{(1)}\right\}}{\sum_{g'=1}^{G} \exp\left\{\frac{\sigma_1}{\sigma_2}\ I_{g's}^{(1)}\right\}} \tag{15}$$

where $I_{gs}^{(1)}$ is the level-1 inclusive value:

$$I_{gs}^{(1)} = \ln\left(\sum_{j\in g} a_{js}\ \exp\left\{\frac{\delta_j}{\sigma_1}\right\}\right) \tag{16}$$

The inclusive value $I_{gs}^{(1)}$ can be interpreted as the expected (maximum) utility of choosing group g in store s given that consumer knows all the product characteristics and the assortment of this store but not the realization of the random shocks $\varepsilon_{ijs}^{(1)}$. Finally, the store choice probabilities are:

$$\mathbb{P}_{\ell s} = \frac{\exp\left\{\dfrac{1}{\sigma_3}\left[\sigma_2\ I_s^{(2)} + Z_s\beta_z + \gamma\ d_{\ell s} + \omega_s\right]\right\}}{1 + \sum_{s'\in R(\ell)} \exp\left\{\dfrac{1}{\sigma_3}\left[\sigma_2\ I_{s'}^{(2)} + Z_{s'}\beta_z + \gamma\ d_{\ell s'} + \omega_s\right]\right\}} \tag{17}$$

where $R(\ell)$ is the set of stores that belong to the consideration set of consumer living in address ℓ, and $I_s^{(2)}$ is the level-2 inclusive value:

$$I_s^{(2)} = \ln\left(\sum_{g=1}^{G} \exp\left\{\frac{\sigma_1}{\sigma_2}\ I_{gs}^{(1)}\right\}\right) \tag{18}$$

The inclusive value $I_s^{(2)}$ can be interpreted as the expected (maximum) utility of patronizing s given that the consumer knows all the product characteristics and the assortment of the store but not the realization of the random shocks $\varepsilon_{ijs}^{(1)}$ and $\varepsilon_{igs}^{(2)}$.

In principle, we could extend our demand model to incorporate random coefficients (consumer heterogeneity) in the parameters β_x, β_z, α, and γ. However, the dataset imposes some restrictions on our ability to identify a model with random coefficients. The main limitation of the dataset is that we do not observe sales for Wine Rack and Wine Shop at store-product level. As we describe in the next section, the nested structure of our demand model, as well as the fact that LCBO sells all Wine Rack and Wine Shop products and that we observe the geographic location of their stores, allow us to deal with this limitation of the data. However, dealing with this data limitation would be substantially more complicated in a model with random coefficients.

As usual, identification of the model requires a normalization of the scale of the unobservables. That is, we can identify the ratios between parameters α/σ_1, σ_1/σ_2, and σ_2/σ_3, but we cannot identify separately $(\alpha, \sigma_1, \sigma_2, \sigma_3)$.

5 Estimation

The demand model is estimated using a two-step method. In a first step, we estimate the parameters β_x/σ_1, α/σ_1, and σ_2/σ_1 using the well-known system of equations in nested logit models of demand (see Cardell, 1997, and Berry, 1994). We use these estimated parameters to construct the store inclusive values $I_s^{(2)}$ using the expression in equation (18). In a second step, we estimate the parameters β_z/σ_3, γ/σ_3, and σ_2/σ_3 based on the spatial logit model of consumer store choice described by equation (17). We now describe these two steps in more detail. We incorporate the time subindex t to emphasize that our dataset covers several months.

5.1 Step 1: Estimation of product choice

For all LCBO stores, the researcher observes the conditional shares $\mathbb{P}_{j|s,g,t}$ and $\mathbb{P}_{g|s,t}$. More specifically, the researcher observes sales $\{q_{jst}\}$ for every LCBO store s and every wine product j available in that store. Then, by definition:

$$\mathbb{P}_{g|s,t} = \frac{\sum_{j \in g} q_{jst}}{\sum_{g'=1}^{G} \sum_{j \in g'} q_{jst}} \quad \text{and} \quad \mathbb{P}_{j|s,g,t} = \frac{q_{jst}}{\sum_{k \in g} q_{kst}} \tag{19}$$

Then, using a logarithm transformation of equations (14) and (15) we get the regression-like equation,

$$\begin{aligned} \ln\left(\mathbb{P}_{j|s,g(j),t}\right) - \ln\left(\mathbb{P}_{1|s,g(1),t}\right) &= \left[\frac{\delta_{jt}}{\sigma_1} - \frac{\delta_{1t}}{\sigma_1}\right] - \frac{\sigma_2}{\sigma_1}\left[\ln\left(\mathbb{P}_{g(j)|s,t}\right) - \ln\left(\mathbb{P}_{g(1)|s,t}\right)\right] \\ &= [X_j - X_1]\ \widetilde{\beta}_x + (-\widetilde{\alpha})\ \ [p_{jt} - p_{1t}] \\ &+ \ (-\widetilde{\sigma}_2)\left[\ln\left(\mathbb{P}_{g(j)|s,t}\right) - \ln\left(\mathbb{P}_{g(1)|s,t}\right)\right] + \xi^*_{jst} \end{aligned} \tag{20}$$

where $j = 1$ is a reference wine product that is available at every LCBO store, $\widetilde{\beta}_x = \beta_x/\sigma_1$, $\widetilde{\alpha} = \alpha/\sigma_1$, $\widetilde{\sigma}_2 = \sigma_2/\sigma_1$, and the error term ξ^*_{jt} is equal to $\xi_{jst} - \xi_{1st}$.

The estimation of this equation should deal with endogeneity problem due to the correlation of the error term ξ^*_{jst} with price p_{jt} and with the market share $\ln\left(\mathbb{P}_{g|s,t}\right)$. We deal with this endogeneity problem by using instrumental variables under two alternative approaches or sets of instruments. A first IV approach consists in the so called *BLP instrumental variables* (Berry, Levinsohn, and Pakes, 1995). The BLP instruments are based on the assumptions that: (i) [independence] observable product characteristics other than price, X, are not correlated with the unobservables ξ; and (ii) [relevance] conditional on X_j the observable characteristics of products other than j, $\{X_k : k \neq j\}$, have explanatory power to predict the price of product j. In our application, the economic interpretation of this second identifying assumption (that is directly testable) is that wholesale prices w_j are the result of oligopoly price competition between wine manufacturers such that the characteristics of all the products affect wholesale prices of all products in equilibrium. Under these conditions, we can use the observable characteristics of products other than j, $\{X_k : k \neq j\}$, as instrumental variables in equation (20). We construct two instruments using the characteristic "alcohol content": the average alcohol content of wines made by the same vintner as product j, and the average alcohol content of wines in the same group as j made by all other makers.

A second IV approach consists in the so called *Arellano-Bond instrumental variables* (Arellano and Bond, 1991). The approach is based on the following structure for the unobservable demand ξ_{jst}:

$$\xi_{jst} = \xi_j^{(1)} + \xi_s^{(2)} + \xi_t^{(3)} + \xi_{jst}^{(4)} \tag{21}$$

where $\xi_{jst}^{(4)}$ is assumed not serially correlated. Note that regression equation (20) implies a difference between log market shares of two products within the same store and time such that $\xi_{jst}^{*} = \xi_{jst} - \xi_{1st} = \xi_j^{*(1)} + \xi_{jst}^{*(4)}$, with $\xi_j^{*(1)} = \xi_j^{(1)} - \xi_1^{(1)}$, and $\xi_{jst}^{*(4)} = \xi_{jst}^{(4)} - \xi_{1st}^{(4)}$. Then, the equation in first differences is (i.e., a differences-in-differences equation for log market shares):

$$\begin{aligned} \Delta \ln \left(\mathbb{P}_{j|s,g,t}\right) - \Delta \ln \left(\mathbb{P}_{1|s,g(1),t}\right) &= (-\widetilde{\alpha}) \ \left[\Delta p_{jt} - \Delta p_{1t}\right] \\ &+ (-\widetilde{\sigma}_2) \ \left[\Delta \ln \left(\mathbb{P}_{g(j)|s,t}\right) - \Delta \ln \left(\mathbb{P}_{g(1)|s,t}\right)\right] + \Delta \xi_{jst}^{*(4)} \end{aligned} \tag{22}$$

The error term of this equation is such that prices and quantities at periods $t-2$ and before are not correlated with $\Delta \xi_{jst}^{*(4)}$. Parameters $\widetilde{\alpha}$ and $\widetilde{\sigma}_2$ can be estimated by GMM using moment conditions based on these instruments. Given these estimates of $\widetilde{\alpha}$ and $\widetilde{\sigma}_2$, we estimate the parameters of the exogenous regressors, $\widetilde{\beta}_x$, by OLS in equation (20) in levels.

5.2 Step 2: Estimation of store choice

Using the estimates in step 1, we calculate the inclusive value $I_{st}^{(2)}$ for every LCBO store-month observation. This inclusive value can be interpreted as the expected utility for a consumer who visits the store. It varies across stores because different stores have different product assortments. Crucially, we can also calculate similar inclusive values for Wine Rack and Wine Shop stores. We know the set of products that Wine Rack and Wine Shop can sell, and we know the characteristics of these products since the LCBO sells them as well. Unlike LCBO stores, we do not know which product assortment each particular Wine Rack or Wine Shop sell. Therefore, we assume that every Wine Rack has the same product assortment (and every Wine Shop has the same product assortment), and this product assortment consists of all the products that the Wine Rack (or Wine

Shop) can sell. While this means that we are somewhat overstating the importance of the Wine Rack and Wine Shop (as there are probably some stores with more limited product assortment), this is not an unreasonable assumption since the number of products they can sell is small - 167 products for Wine Rack and 116 products for Wine Shop. An average LCBO, by comparison, sells approximately 180 different Ontario wine SKUs. Furthermore, all WR and WS products are very popular such that it seems reasonable that every store within the chain includes almost all the products. Under this assumption, we can construct the expected utility that a consumer would obtain from visiting a Wine Rack store or a Wine Shop store.

Define $Q_{st} \equiv \sum_{j=1}^{J} q_{jst}$ as the total sales of wine, in physical units, by store s at month t. This variable is observable in our data for every LCBO store. The model of store choice implies that:

$$Q_{st} = \sum_{\ell:\ s \in R(\ell)} \frac{H_\ell \ \exp\left\{\rho\ I_{st}^{(2)} + \beta_{chain(s)} + \gamma\ d_{\ell s} + \omega_{st}\right\}}{1 + \sum_{s' \in R(\ell)} \exp\left\{\rho\ I_{s't}^{(2)} + \beta_{chain(s')} + \gamma\ d_{\ell s'} + \omega_{s't}\right\}} \tag{23}$$

where $\rho \equiv \sigma_2/\sigma_3$, $\beta_{chain(s)} = \beta_{LCBO}\ D_s^{LCBO} + \beta_{WR}\ D_s^{WR} + \beta_{WS}\ D_s^{WS}$, and D_s^{LCBO}, D_s^{WR}, and D_s^{WR} are dummy variables that represent the retail chain of store s. Variable H_ℓ is market size (measured in 750 ml bottles of wine) and it is partially observable to the researcher. More specifically,

$$H_{\ell t} = H^{obs}\ \exp\{Z_\ell\ \theta\} \tag{24}$$

H_ℓ^{obs} is a measure of market size based on the population in location ℓ and on the average consumption of wine in Ontario (i.e., H_ℓ^{obs} is also measured in 750 ml bottles of wine). The term $\exp\{Z_\ell\ \theta\}$ captures the effect of other consumer characteristics that may affect the effective market size in location ℓ, where Z_ℓ is a vector of observable demographic characteristics such as the logarithm of average household income, population density, or an urban-location dummy, and θ is a vector of parameters.

$R(\ell)$ represents the set of stores in the consideration of consumers with home address ℓ. For the construction of consumers' home addresses, we assume that all consumers within a census tract (for urban areas) or a census subdivision (for rural areas) are located at the geographic centroid of the tract or subdivision. For the construction of consumer consideration sets, we assume that urban consumers are willing to travel as far as 3 km to buy wine such that an urban consumer consideration set includes all the stores within a 3 km radius around the geographic centroid of her census tract. For rural consumers we consider a 10km radius.

Based on our definition of consumers consideration sets, we can make a partition of the region under study, Ontario, into "isolated" submarkets. An isolated submarket is a cluster of stores such that for every store in this cluster, consumers' consideration sets include only stores within the cluster. This partition can be described either over the set of store locations $\mathcal{S} = \{s = 1, 2, ..., S\}$ or over the set of consumer locations (census tracts) $\mathcal{L} = \{\ell = 1, 2, ..., L\}$. The two representations are equivalent of isomorphic.

DEFINITION. Submarket. Consider a set of consumer locations $\mathcal{L} = \{\ell = 1, 2, ..., L\}$, a set of store locations $\mathcal{S} = \{s = 1, 2, ..., S\}$, and the *consumer consideration mapping* $C(\ell)$ from $\mathcal{L}$ into $\mathcal{S}$ that provides the consideration set of every consumer. Let $C^{-1}(.)$ be the inverse of the *consumer consideration mapping* such that $C^{-1}(s)$ represents the set of consumer locations that have store s in their consideration sets. We define a submarket m as a subset of stores $\mathcal{S}_m \subseteq \mathcal{S}$ that satisfies the following condition: for every store $s \in \mathcal{S}_m$, we have that $C\left(C^{-1}(s)\right) \subseteq \mathcal{S}_m$.

We provide a formal algorithmic description of our construction of submarkets in Appendix C. This concept of submarket is important for the solution and estimation of the spatial demand model. We can treat each submarket as an independent demand system, and apply Berry (1994) invertibility Theorem separately to each submarket. This reduces very substantially the computation time in the solution and estimation of this spatial demand model.

Table 3 presents the empirical distribution of submarkets according to the number of consumer locations, and of LCBO, WR, and WS stores. There are 220 submarkets in Ontario. Of these, 141 submarkets consists of only one consumer location (i.e., one consumer consideration set circle). There are 155 submarkets without a Wine Rack or Wine Shop stores. Note every submarket has at least one LCBO store.

Table 3
Empirical Distribution of Submarket Types

Consumer consideration sets:
Urban: 3Km radius around centroid of census track; Rural: 10Km radius around centroid of census subdivision

	A single consumer location	Multiple consumer locations	Total
[One LCBO store] & [Zero WR or WS]	115	19	134
[Multiple LCBO stores] & [Zero WR or WS]	13	8	21
[One LCBO store] & [Some WR or WS]	8	18	26
[Multiple LCBO stores] & [Zero WR or WS]	5	34	39
[Zero LCBO stores] & [Some WR or WS]	0	0	0
Total	141	79	220

An important issue in the estimation of the parameters of this store choice model comes from the fact that our dataset includes sales data $\{Q_{st}\}$ only for LCBO stores but not for WR and WS stores. We now describe our approach to deal with this data limitation. For the sake of simplicity in the description of the estimation method, we consider here the subsample of submarkets with only one consumer location. This subsample accounts for 141 of the total 220 submarkets. We can use the index of consumer locations, ℓ, to index these submarkets.

Define the aggregate sales of LCBO in submarket ℓ as $Q_{\ell t}^{LCBO}$. For a submarket with only one consumer location, we have that $Q_{\ell t}^{LCBO}$ is just the sum of sales over all the LCBO stores in the consideration set $R(\ell)$, i.e., $Q_{\ell t}^{LCBO} \equiv \sum_s 1\{s \in R(\ell) \text{ and } s \in LCBO\}\ Q_{st}$, where $1\{.\}$ is the indicator function. Therefore, $H_\ell - Q_{\ell t}^{LCBO}$ is the number of consumers in location ℓ who choose not to buy at LCBO (i.e., they choose either the outside alternative, or WR, or WS), and $Q_{st}/(H_\ell - Q_{\ell t}^{LCBO})$ is the ratio between the number of consumers who chose LCBO store s and those who choose not to buy at LCBO stores. Note that this ratio is observable to the researcher up to the vector of parameters θ in the measure of market size. Let $y_{\ell st}(\theta)$ be the logarithm of this ratio, i.e., $y_{\ell st}(\theta) \equiv \ln(Q_{st}) - \ln\left(H_\ell^{obs}\ \exp\{Z_\ell\ \theta\} - Q_{\ell t}^{LCBO}\right)$. The model implies the following regression equation for $y_{\ell st}(\theta)$: for any LCBO store s within a submarket with only one consumer location:

$$y_{\ell st}(\theta) \quad = \quad \beta_{LCBO} + \rho \; I_{st}^{(2)} + \gamma \; d_{\ell s} - \ln\left(1 + \exp\{I_{WR,\ell}^{(3)}\} + \exp\{I_{WS,\ell}^{(3)}\}\right) + \omega_{\ell st} \qquad (25)$$

where $I_{WR,\ell}^{(3)}$ and $I_{WS,\ell}^{(3)}$ are the inclusive values:[23]

$$\begin{aligned} I_{WR,\ell}^{(3)} &= \ln\left(\textstyle\sum_{s' \in R(\ell)} D_{s'}^{WR} \; \exp\left\{\beta_{WR} + \rho \; I_{WR}^{(2)} + \gamma \; d_{\ell s'}\right\}\right) \\ I_{WS,\ell}^{(3)} &= \ln\left(\textstyle\sum_{s' \in R(\ell)} D_{s'}^{WS} \; \exp\left\{\beta_{WS} + \rho \; I_{WS}^{(2)} + \gamma \; d_{\ell s'}\right\}\right) \end{aligned} \qquad (26)$$

Note that for WR and WS stores the inclusive values $I_{WR}^{(2)}$ and $I_{WS}^{(2)}$, that account for the store assortments, are constant over time and over all the stores within the same chain. The identification of the coefficients associated to chain brand dummies (β_{WR} and β_{WS}) separately form the effect of chain assortments ($\rho \; I_{WR}^{(2)}$ and $\rho \; I_{WS}^{(2)}$) is possible because the parameter ρ is identified from sample variation in the assortments (in $I_{st}^{(2)}$) across LCBO stores.

We estimate the vector of parameters ($\theta, \rho, \gamma, \beta_{LCBO}$,$\beta_{WR}, \beta_{WS}$) using a GMM procedure that exploits three sets of moment conditions. A main econometric issue in the estimation of equation (25) is the potential endogeneity of the inclusive values $I_{st}^{(2)}$ that capture store assortment decisions, and of the dummy variables D_s^{WR} and D_s^{WS} that represent the presence of WR and WS stores in the market. We expect these variables to be positively correlated with the unobservable variable ω_{st}. Submarkets with higher unobserved demand ω_{st} may have LCBO stores with better assortment (i.e., higher values of $I_{st}^{(2)}$) and higher likelihood of presence of WR and WS stores. Furthermore, distances between consumers and stores, $d_{\ell s}$, may be also correlated with unobserved market characteristics. For instance, markets with higher unobserved demand may have also higher density of stores such that the distances $d_{\ell s}$ would be smaller. This correlation would generate an upward bias in the estimate of consumer transportation costs. We now describe our identification assumptions to deal with these endogeneity issues.

Dealing with the endogeneity of the assortment inclusive values $I_{st}^{(2)}$ is relatively easier because these variables have some variation over time that is partly exogenous because prices do not respond to submarket-specific demand shocks. We assume that the error term $\omega_{\ell st}$ has the following component structure $\omega_{\ell st} = \omega_{\ell}^{(1)} + \omega_t^{(2)} + \omega_{\ell st}^{(3)}$, where $\omega_{\ell st}^{(3)}$ is not serially correlated. Then, under the assumption of no serial correlation in $\omega_{\ell st}^{(3)}$ we have that $\mathbb{E}\left(I_{st-r}^{(2)} \; \Delta\omega_{\ell st}^{(3)}\right)$ for any $r \geq 2$, such that we can use $I_{st-r}^{(2)}$ as a valid instrument in equation (25) in first differences. More precisely, we

[23] We impose the restriction that for WR and WS stores there are not idiosyncratic unobservable shocks ω_{st}, i.e., $\omega_{st} = 0$ for $s \in \{WR, WS\}$.

identify ρ from the Arellano-Bond moment conditions:

$$\mathbb{E}\left(I^{(2)}_{st-r}\ \left[\Delta y_{\ell st}(\alpha) - \rho\ \Delta I^{(2)}_{st} - \Delta\omega^{(3)}_{t}\right]\right) = 0 \tag{27}$$

for $r \geq 2$.

Our identification of the transportation cost parameter γ takes into account that the distances between consumers and stores may be correlated with unobserved market characteristics. Including observable market characteristics Z_ℓ in the estimation (e.g., population density, urban dummy) can alleviate, at least partly, this endogeneity problem, but the remaining error $\omega^{(1)}_\ell$ may be correlated with store distances. We consider a fixed effect approach. For those submarkets, with at least two LCBO stores, we estimate γ using the following moment conditions:

$$\mathbb{E}\left(\widetilde{d_{\ell s}}\ \left[\left(\widetilde{y_{\ell st}}(\alpha) - \rho\ \widetilde{I^{(2)}_{st}}\right) - \gamma\ \widetilde{d_{\ell s}}\right]\right) = 0 \tag{28}$$

where the variables with the tilde $\sim$ symbol are in deviations with respect to submarket means, i.e., $\widetilde{d_{\ell s}} \equiv d_{\ell s} - N_\ell^{-1}\sum_{s' \in R(\ell)} d_{\ell s'}$.

The identification of the parameters β_{WR} and β_{WS} is based on the assumption that, after controlling for observable market characteristics Z_ℓ, the location of Wine Rack and Wine Shop stores in year 2006 is not correlated with the unobservable demand $\omega^{(1)}_\ell$ in sample years 2011-2013, though it is correlated with the location of these stores in the sample periods.[24] This assumption implies the moment conditions:

$$\mathbb{E}\left(Z^*_\ell\left[y^*_{\ell st} + \ln\left(1 + \exp\{I^{(3)}_{WR,\ell}\} + \exp\{I^{(3)}_{WS,\ell}\}\right)\right]\right) = 0 \tag{29}$$

where $y^*_{\ell st} \equiv y_{\ell st}(\theta) - \rho\ I^{(2)}_{st} - \gamma\ d_{\ell s}$, $Z^*_\ell \equiv (Z_\ell, I^{(3)}_{WR,\ell,2006}, I^{(3)}_{WS,\ell,2006})$, and the instrumental variables $I^{(3)}_{WR,\ell,2006}$ and $I^{(3)}_{WS,\ell,2006}$ have the same definition as the inclusive values $I^{(3)}_{WR,\ell}$ and $I^{(3)}_{WS,\ell}$ but using the network of stores in year 2006 instead of 2011.

The system of moment conditions (27), (28), and (29) have a recursive structure. We first obtain consistent estimates of the parameters in a recursive way: in step 1, we estimate ρ using (27); in step 2, we estimate γ using (28); and in step 3, we estimate $\theta's$ and β's using (29). Finally, we use these estimates as initial values and apply one-step Newton iteration in the joint GMM method to obtain a more efficiency estimator as well as correct standard errors.

[24] Between 2006 and 2012, there has been some store reallocation. Approximately 40 Wine Racks and 20 Wine Shops moved over that period. Since this reallocation essentially stopped in 2013 and 2014, it was likely driven by two developments - the takeover of the Wine Rack by the US based company Constellation Brands in 2006, and the introduction of more Wal-Marts to Canada. With regards to the first development, it is likely that Constellation Brands decided to push their products more aggressively in the Ontario market. With regards to the second development, senior VinCor managers are on record stating that they wish to reallocate more stores into Wal-Marts to receive more exposure.

6 Empirical results

6.1 Estimation of demand

6.1.1 Step 1: Estimation of product choice

Table 4 presents our estimates of demand parameters in step 1. We report estimates using three methods: OLS, GMM with BLP instruments, and GMM with Arellano-Bond instruments. Despite the identification assumptions behind BLP and Arellano-Bond instruments are quite different, we find that the two sets of IV estimates are very similar, and significantly different than the OLS estimates. In particular, the IV estimate of the price coefficient is substantially larger in absolute terms than the OLS estimate. This suggests that there is indeed an endogeneity problem in the OLS regression.

Table 4
Demand Estimation. Step 1. Product Choice

Parameter (Variable)	(1) OLS	(2) BLP-IV	(3) Arellano-Bond
$\widetilde{\alpha}$ (- Price)	0.115 (0.000)***	0.407 (0.000)***	0.378 (0.002)***
$\widetilde{\sigma}_2$ (- Within group market share)	1.674 (0.003)***	1.500 (0.011)***	1.864 (0.050)***
$\widetilde{\beta}_{alcohol}$ (Alcohol)	0.169 (0.001)***	0.314 (0.001)***	0.299 (0.003)***
Observations	5,117,154	5,117,154	5,117,154
Time Fixed Effects	YES	YES	YES
Store Fixed Effects	YES	YES	YES

Note: Robust standard errors in parentheses
* means $p < 0.05$; ** means $p < 0.01$; *** means $p < 0.001$.

The within-group own-price elasticity of demand for product j in group g is equal to $-\widetilde{\alpha}\ (1 - \mathbb{P}_{j|g})\ p_j$. The median price for an Ontarian product is \$13 (see Table 1 above). The median within-group market share for an Ontarian product is approximately 0.5%. Using a value of $\widetilde{\alpha} = 0.400$, we have that the median of the within-group own-price elasticity is -5.17 (i.e., $-0.4 \times 0.995 \times 13$). This seems a reasonable within-group elasticity. Note that the total and the within-store own-price elasticities are smaller than the within-group elasticities.

Seim and Waldfogel (2013) find that price elasticity for "alcohol" (defined as a composite product including wine, beer, and liquor) varies between 0.7 and 1.9. Chaloupka, Grossman, and Saffer (2002) cite estimates of the price elasticity of demand for wine (the product group as a whole) as approximately 1. However, these studies look at the demand elasticities of groups of products, rather than individual products. The demand for wine as a whole, or for alcohol as a whole should be fairly more inelastic than the within-group elasticity due to the presence of many close substitutes within a group.

A group's own elasticity of demand with respect to its inclusive value is equal to $\frac{\sigma_1}{\sigma_2}\,(1-\mathbb{P}_{g|s})\,I_{gs}^{(1)}$, with $\frac{\sigma_1}{\sigma_2} = \frac{1}{\widetilde{\sigma}_2}$. The average inclusive value for Ontarian products is 10.6, and the average market share of Ontarian products is approximately 30%. Therefore, using a value $\widetilde{\sigma}_2 = 1.75$ we have that the between-groups (within-store) elasticity for Ontario products is 4.24 (i.e., $(1/1.75)\times 0.7\times 10.6$). This means that demand for Ontario products as a whole (and for foreign products as well) is highly elastic. Similarly, this elasticity for Foreign wines is equal to 2.21 (i.e., $(1/1.75)\times 0.3\times 12.9$). It is quite reasonable that the demand for foreign products is less elastic than for Ontario products, since there are generally more foreign varieties available at a given store, and there is more differentiation across varieties. This matters since if the overall value of the foreign product group declines, it does not necessarily mean that all products have lower value. As a result, we would not expect the demand for foreign products to drop as drastically as for Ontario products.

The cross elasticity between Ontarian and Foreign groups within a store is equal to $-\frac{\sigma_1}{\sigma_2}\,\mathbb{P}_{\mathcal{F}|s}\,I_{\mathcal{F}s}^{(1)}$. Using average inclusive values and market shares and a value $\widetilde{\sigma}_2 = 1.75$, this elasticity is equal to -5.26 (i.e., $-(1/1.75)\times 0.7\times 12.9$) - a one percent decline in the value of the foreign group increases the market share of the Ontario group by 5.26 percent. The corresponding elasticity for the foreign group is approximately -1.81 (i.e., $-(1/1.75)\times 0.3\times 10.6$). The much larger and more varied foreign product group is less affected by changes in the value of the Ontario group than vice versa.

6.1.2 Step 2: Estimation of store choice

Table 5 presents the estimates of the demand parameters associated to the store choice part of the model.

Using the γ parameter we can calculate the dollar value of the dis-utility of distance for wine consumers in Ontario. We estimate that this dis-utility is approximately -0.75 per kilometer; that is, a wine consumer in Ontario loses 75 cents in utility (per 750 ml bottle) by travelling for an additional kilometer. These estimates are relatively close to the estimates of Seim and Waldfogel (2013), who estimated the dis-utility of distance for a generic 750 ml alcohol product to be 50 cents per kilometer.

Table 5
Demand Estimation. Step 2. Store Choice

Parameter (Variable)	(1) OLS	(2) IV
ρ ($\equiv \sigma_2/\sigma_3$) (Store Inclusive Value)	0.931 (0.087)***	0.767 (0.103)***
γ (- Distance Store-Consumers)	0.190 (0.029)***	0.178 (0.069)***
Observations	4,841	4,841
R-square	0.66	
Time Fixed Effects	YES	YES
Store Fixed Effects	YES	YES

Note: Robust standard errors in parentheses
* means p < 0.05; ** means p < 0.01; *** means p < 0.001.

6.2 Counterfactuals

We have obtained estimates of the changes in sales, market shares, government revenues and consumer surplus under two counterfactual experiments: (Counterfactual i) where we eliminate Wine Racks and Wine Shops stores; and (Counterfactual iii) where Wine Rack and Wine Shop can carry additional products. For this Counterfactual (iii), we expand the product selection of every Wine Rack and Wine Shop to include the LCBO's top 100 selling products.[25] Note, however, that we currently assume that every WR and WS simply carries an additional 100 products, rather than replacing any of their existing Ontario wines.

Note that since we have not yet recalculated the pricing decisions of the LCBO, our counterfactuals hold two important factors constant, which may affect the predictions of the model. First, they hold the number of LCBO stores constant in the counterfactual scenarios where there are no more WR and WS. However, in the absence of competitors, it is possible that the LCBO could have constructed more stores - in part because it would be less concerned with business stealing. This means that our calculations are a lower bound on the counterfactual sales of the LCBO.

As well, the LCBO could set different prices (mark-ups) in the absence of competition, or with the WR and WS carrying foreign products. For the moment, we do not consider those changes.

6.2.1 Sales and Market Shares

Table 6 represents changes in Ontario wine market shares, in the (combined) market share of the Wine Rack and Wine Shop in Ontario, and the total change in sales between the baseline estimates

[25] Now, a WR carries approximately 260 products, and a WS carries approximately 200 products.

and the two counterfactuals:

Table 6
Counterfactual Sales and Market Shares

	ON Mkt Share	WR/WS Mkt Share	% Δ Sales Relative to Baseline
LCBO Monopoly	43.3%	0%	- 5.1%
Baseline Estimates	52.2%	15.9%	-
More WR/WS Products	43.5%	23.8%	+ 0.2%

Note: Actual WR/WS market share is 14.8%. Prices and store locations are constant throughout.

These estimates suggest that increasing the number of stores available for consumers in the market (e.g. moving from only having LCBO stores to LCBO, WR, and WS stores) increases total sales by approximately 5 percent. However, increasing the number of products available at existing stores does not generate a corresponding increase in sales. While the sales of the WR and WS increase when they have more products - their market share increases by 10 % - but these increases come at the expense of the LCBO's sales - a business stealing effect.

Note also that Ontario product market shares are highest when the WR and WS exist in the market but can only sell Ontario products. This makes sense, since if the WR and WS carry foreign wines, at least some consumers will substitute to those. If the WR and WS do not exist in the market and consumers can only go to LCBOs, then they will find it more costly to buy Ontario wines (on average) and will substitute more to foreign wines.

6.2.2 Variable profits, tax revenues, and consumer surplus

Table 7represents changes in the variable profits of the LCBO, the WR and WS, total Ontario government revenues[26], and total consumer surplus in the market, between the three counterfactuals.

[26] These include the LCBO profits, and the total amount of tax money obtained by the Ontario government from the sale of alcohol in the province. It does not currently include any taxes that the WR and WS have to pay to the Ontario government to operate in the market.

Table 7
Counterfactual Profits, Government Revenue, and Consumer Surplus

	LCBO Profits (millions/month)	WR/WS Profits (millions/month)	Total Ontario Gov't Revenues (millions/month)	Δ Consumer Surplus (%)
LCBO Monopoly	49.7	0	63.6	- 5.4
Baseline	44.1	6.7	58.5	-
More WR/WS Products	40.0	10.3	54.4	+ 2.8

Note: Prices and store locations are constant throughout.

These results confirm the sales effects, by showing that increasing the number of stores increases producer surplus - total producer variable profits go from 49.7 to over 50 million per month. It also increases consumer surplus, suggesting that total welfare in the market increases. This is consistent with previous work - e.g. Seim and Waldfogel (2013).

However, increasing the number of products available in the market only serves to reallocate (and even slightly reduce) producer surplus via a business stealing effect - total variable profits go to 50.3 million per month, although WR and WS profits almost double. That said, although sales (and producer surplus) barely increase from an increase in the number of products at the WR and WS, consumer surplus increases fairly substantially. This is likely because consumers now have more options and are better able to find options that fit their idiosyncratic tastes. As a result of these improved matches, total consumer surplus increases.

Note that total government revenues fall with subsequent increases in competition. This happens as the LCBO sales fall with more and more competition in the market, which reduces the amount of LCBO profits, which contribute directly to government revenues. These lost revenues cannot be fully recouped from taxes on the Wine Rack or Wine Shop - since the government would have to essentially tax their entire profits away to maintain its revenues between the different counterfactuals. Of course, with endogenous changes in prices, the government could recoup some of those lost revenues.

7 Conclusions

With a detailed product and SKU level dataset giving me data on prices and inventories (as a proxy for sales), this study compares sales, profits, consumer welfare, and government revenues under two regulatory environments in the wine retail market in Ontario using a structural nested logit demand model with differentiated products and stores - a monopoly environment with a government owned retail chain, and a partially deregulated environment with asymmetric competition. The partial deregulation allows two privately owned chains to enter the market with a limited number of stores and sell a restricted subset of wines (only Ontario-grown wines) in addition to the government owned retail chain (which sells all types of wine). This comparison follows the gradual actual historical deregulation policies much more closely than previous work on this market (e.g. Seim and Waldfogel 2013), which compares outcomes between a monopoly market and an symmetric free entry market.

Compared to the monopoly state, we estimate that the sales of the "competitive subset" (i.e. the Ontario-grown wines) increase by approximately 50 percent under limited competition, far above the business stealing effect.[27] However, the sales of foreign wines are lower in the competitive state, suggesting that having additional and more conveniently located stores selling only Ontario wines encourages substitution towards these products and away from foreign wines. As a result of the lower sales of foreign wine, overall aggregate sales (or both Ontario and foreign grown products) are at most 7% higher in the competitive state. We also estimate that consumer surplus is at most 5% higher under the limited competition state as compared to the monopoly state. Previously, Seim and Waldfogel (2013) estimated that a free entry regime increases consumption by about 15% compared to a monopoly regime, with an attendant 9% increase in consumer surplus - about double my estimates. This suggests the substantial limitation of free entry counterfactuals in generating predictions for other policy interventions in this market - such as moving from a monopoly market to a market with limited competition (as in my model), or in moving from a limited competition market to a free entry market.

We estimate that variable producer profits (which do not include the fixed costs of operation) are 4.5% higher in the competitive market than in the monopoly market. This suggests that aggregate welfare is higher under the limited competition than under monopoly.[28] However, we also estimate that aggregate revenues to the Ontario government are lower under limited competition than under a monopoly, as the fall in the sales of the state owned retail chain is not fully compensated by the increase in tax revenues due to greater sales of Ontario-grown products. Moreover, the government

[27] Note that I keep the number of the government owned retailer's stores constant between the two regimes, which likely overstates this effect. I also keep prices and product assortment constant.

[28] Even though I do not account for differences in fixed costs between the two states, differences in consumer surplus are of an order of magnitude larger than differences in producer surplus, which suggests that overall welfare would increase even if the change in producer surplus was negative.

could also likely improve their revenues by allowing the competitor chains to carry more products (including foreign products), which would increase sales and their tax revenues further. This suggests that by allowing the competitor chains to remain in the market (while selling limited product variety), the Ontario government promotes substitution towards the Ontario-grown wines sold by these competitors at the expense of public revenues - an effective subsidy to the producers of these specific Ontario wines. While this is fully consistent with the Ontario government's mandate to promote the sales of Ontario wines, the fact that this subsidy is targeted towards particular producers may raise questions regarding the efficiency of such industrial policy.

As for my next steps: while the nested logit model is relatively easy to estimate and produces some interesting results, in the future We intend to extend the model into random coefficients, which would allow for more flexible and realistic substitution patterns across products, stores and retailers. Additionally, we intend to allow the LCBO to change the mark-ups between the two different states. The LCBO sets the mark-ups in conjunction with the Ontario Ministry of Finance and does not change them frequently. As a result, it is reasonable to assume that the mark-ups would be the same under a monopoly and under the very limited form of competition. However, given that the LCBO can adjust their mark-ups, it would be interesting to see how they would change them.

Lastly, a key limitation to the methodology above is that we assume that LCBO stores are exogenously located and that they do not enter or exit markets (or change their product assortment). As a result, we may bias my coefficient estimates in the last nest. Furthermore, since we do not account for LCBO store entry, we have to assume that no new LCBO stores open in the counterfactual state where the Wine Rack and Wine Shop do not exist, which limits the interpretation of my counterfactuals. Thus, we need to account for the entry of LCBO stores in local markets and to generate entry counterfactuals.

To do this, we would like to estimate the entry/product selection game. This should be complex, as due to province wide entry restrictions on the Wine Rack and Wine Shop, they maximize profits across the province all at once (see Equation 11). This means it would be incorrect to estimate a standard entry game with independent entry (as in Seim, 2006, or Aguirregabiria and Mira, 2007), since there is inter-dependence in entry decisions across markets - the shocks received by a retailer in one market can affect their entry decisions in another market. Nonetheless, it may be possible to use moment inequalities to estimate bounds on entry parameters (such as the fixed costs or entry costs), a la Ellickson et al (2013).

Appendix A. Derivation of Optimal Markups

The Lagrange representation of LCBO pricing problem is:

$$\max_{\{m_{\mathcal{O}},m_{\mathcal{F}}\}} \quad \sum_{j\in\mathcal{O}} [m_{\mathcal{O}}\ w_j - \lambda_{\mathcal{O}}]\ \ D_j(\mathbf{p}) + \sum_{j\in\mathcal{F}} [m_{\mathcal{F}}\ w_j - \lambda_{\mathcal{F}}]\ \ D_j(\mathbf{p})$$

The first order condition of optimality with respect to $m_{\mathcal{O}}$ is:

$$W_{\mathcal{O}} + \sum_{j\in\mathcal{O}} [m_{\mathcal{O}}\ w_j - \lambda_{\mathcal{O}}] \frac{\partial q_j}{\partial m_{\mathcal{O}}} + \sum_{j\in\mathcal{F}} [m_{\mathcal{F}}\ w_j - \lambda_{\mathcal{F}}] \frac{\partial q_j}{\partial m_{\mathcal{O}}} = 0$$

where $W_{\mathcal{O}} \equiv \sum_{j\in\mathcal{O}} w_j q_j$ is total wholesale cost for Ontario wines. And we have a similar marginal condition of optimality with respect to $m_{\mathcal{F}}$. For any product j, and for $G = \mathcal{O}, \mathcal{F}$, we have that:

$$\begin{aligned}
\frac{\partial q_j}{\partial m_G} &= \sum_{k\in G} \frac{\partial q_j}{\partial p_k}\frac{\partial p_k}{\partial m_G} = \sum_{k\in G} \frac{\partial q_j}{\partial p_k}\frac{p_k}{q_j}\frac{q_j}{p_k}(1+\tau)\, w_k \\
&= -\left[\frac{q_j}{1+m_G}\right]\left[\sum_{k\in G} \eta_{jk}\frac{(1+m_G)w_k}{(1+m_G)w_k+\kappa}\right] \\
&= -\left[\frac{q_j}{1+m_G}\right]\eta_{jG}
\end{aligned}$$

where η_{jk} is the demand elasticity of product j with respect to the price of product k; and $\eta_{jG} \equiv \sum_{k\in G} \eta_{jk}\ \phi_{kG}$, with $\phi_{kG} \equiv \dfrac{1}{1+\frac{\kappa}{(1+m_G)w_k}}$. In our case, $\kappa = \$1.52$ is small relative to the whole price and to and to $(1+m_G)w_k$, and the variables ϕ_{kG} are practically equal to 1 for all the product. Therefore, we can interpret η_{jG} as the demand elasticity of product j with respect to a marginal increase in the prices of all the products in group G. Solving this expression into the first order condition of optimality, we get:

$$W_{\mathcal{O}} - \sum_{j\in\mathcal{O}} [m_{\mathcal{O}}\ w_j - \lambda_{\mathcal{O}}]\left[\frac{q_j\ \eta_{j\mathcal{O}}}{1+m_{\mathcal{O}}}\right] - \sum_{j\in\mathcal{F}} [m_{\mathcal{F}}\ w_j - \lambda_{\mathcal{F}}]\left[\frac{q_j\ \eta_{j\mathcal{O}}}{1+m_{\mathcal{O}}}\right] = 0$$

Let $\overline{w}_G$ be the weighted average of wholesale prices in group G where each product is weighted by its share in the group sales Q_G, i.e., $\overline{w}_G \equiv \sum_{j\in\mathcal{G}} w_j \left[\frac{q_j}{Q_G}\right]$. Define the parameter $\tau_G \equiv \frac{\lambda_G}{\overline{w}_G}$, that is a representation of the Lagrange multiplier λ_G as a percentage of the average wholesale price. Also, define $\eta_{\mathcal{O}\mathcal{F}}$, $\eta_{\mathcal{O}\mathcal{F}}$, $\eta_{\mathcal{F}\mathcal{O}}$, and $\eta_{\mathcal{F}\mathcal{F}}$ as weighted averages of the product-specific elasticities η_{jG} where each product is weighted by its share in the wholesale cost. And similarly, let $\widetilde{\eta}_{\mathcal{O}\mathcal{O}}$, $\widetilde{\eta}_{\mathcal{O}\mathcal{F}}$, $\widetilde{\eta}_{\mathcal{F}\mathcal{O}}$, and $\widetilde{\eta}_{\mathcal{F}\mathcal{F}}$ be also weighted averages of product-specific elasticities η_{jG} where now each product is weighted by its share in sales. More specifically,

$$\begin{array}{lcl}
\eta_{\mathcal{O}\mathcal{O}} \equiv \sum_{j\in\mathcal{O}} \eta_{j\mathcal{O}} \left[\frac{w_j\ q_j}{W_{\mathcal{O}}}\right] & ; & \widetilde{\eta}_{\mathcal{O}\mathcal{O}} \equiv \sum_{j\in\mathcal{O}} \eta_{j\mathcal{O}} \left[\frac{\overline{w}_{\mathcal{O}}\ q_j}{W_{\mathcal{O}}}\right] \\
\eta_{\mathcal{O}\mathcal{F}} \equiv \sum_{j\in\mathcal{F}} \eta_{j\mathcal{O}} \left[\frac{w_j\ q_j}{W_{\mathcal{F}}}\right] & ; & \widetilde{\eta}_{\mathcal{O}\mathcal{F}} \equiv \sum_{j\in\mathcal{F}} \eta_{j\mathcal{O}} \left[\frac{\overline{w}_{\mathcal{F}}\ q_j}{W_{\mathcal{F}}}\right] \\
\eta_{\mathcal{F}\mathcal{O}} \equiv \sum_{j\in\mathcal{O}} \eta_{j\mathcal{F}} \left[\frac{w_j\ q_j}{W_{\mathcal{O}}}\right] & ; & \widetilde{\eta}_{\mathcal{F}\mathcal{O}} \equiv \sum_{j\in\mathcal{O}} \eta_{j\mathcal{F}} \left[\frac{\overline{w}_{\mathcal{O}}\ q_j}{W_{\mathcal{O}}}\right] \\
\eta_{\mathcal{F}\mathcal{F}} \equiv \sum_{j\in\mathcal{F}} \eta_{j\mathcal{F}} \left[\frac{w_j\ q_j}{W_{\mathcal{F}}}\right] & ; & \widetilde{\eta}_{\mathcal{F}\mathcal{F}} \equiv \sum_{j\in\mathcal{F}} \eta_{j\mathcal{F}} \left[\frac{\overline{w}_{\mathcal{F}}\ q_j}{W_{\mathcal{F}}}\right]
\end{array}$$

Using these definitions, the marginal condition of optimality can be represent as:

$$m_{\mathcal{O}}\ (\eta_{\mathcal{O}\mathcal{O}}-1)-\tau_{\mathcal{O}}\ \widetilde{\eta}_{\mathcal{O}\mathcal{O}}+m_{\mathcal{F}}\left(\frac{W_{\mathcal{F}}}{W_{\mathcal{O}}}\right)\eta_{\mathcal{O}\mathcal{F}}-\tau_{\mathcal{F}}\left(\frac{W_{\mathcal{F}}}{W_{\mathcal{O}}}\right)\widetilde{\eta}_{\mathcal{O}\mathcal{F}} \quad = \quad 1$$

Similarly, the marginal condition of optimality with respect to $m_{\mathcal{F}}$ implies:

$$m_{\mathcal{F}}\ (\eta_{\mathcal{F}\mathcal{F}}-1)-\tau_{\mathcal{F}}\ \widetilde{\eta}_{\mathcal{F}\mathcal{F}}+m_{\mathcal{O}}\left(\frac{W_{\mathcal{O}}}{W_{\mathcal{F}}}\right)\eta_{\mathcal{F}\mathcal{O}}-\tau_{\mathcal{O}}\left(\frac{W_{\mathcal{O}}}{W_{\mathcal{F}}}\right)\widetilde{\eta}_{\mathcal{F}\mathcal{O}} \quad = \quad 1$$

When the number of products J is large (i.e., $J\to\infty$) and every product share $\frac{w_j\ q_j}{W}$ and $\frac{q_j}{Q}$ goes to zero, we have that the average elasticities $\widetilde{\eta}_{GG'}$ and $\eta_{GG'}$ become the same, i.e., $\lim_{J\to\infty}[\widetilde{\eta}_{GG'}-\eta_{GG'}]=0$. In our application, with more than $8,500$ products and a maximum value of the shares $\frac{q_j}{Q}$ that is smaller than 1%, we have that these two weighted average elasticities are practically identical. Therefore, here we assume that $\widetilde{\eta}_{GG'}=\eta_{GG'}$. Solving for $m_{\mathcal{O}}$ in this system of equations, we get:

$$m_{\mathcal{O}} \quad = \quad \frac{1}{\eta_{\mathcal{O}\mathcal{O}}-1}+\frac{\eta_{\mathcal{O}\mathcal{O}}\ \tau_{\mathcal{O}}}{\eta_{\mathcal{O}\mathcal{O}}-1}+\frac{\eta_{\mathcal{O}\mathcal{F}}\ \left[\eta_{\mathcal{F}\mathcal{O}}\ \ (m_{\mathcal{O}}-\tau_{\mathcal{O}})-\left(\frac{W_{\mathcal{F}}}{W_{\mathcal{O}}}\right)(1+\tau_{\mathcal{F}})\right]}{(\eta_{\mathcal{O}\mathcal{O}}-1)(\eta_{\mathcal{F}\mathcal{F}}-1)}$$

and

$$m_{\mathcal{F}} \quad = \quad \frac{1}{\eta_{\mathcal{F}\mathcal{F}}-1}+\frac{\eta_{\mathcal{F}\mathcal{F}}\ \tau_{\mathcal{O}}}{\eta_{\mathcal{F}\mathcal{F}}-1}+\frac{\eta_{\mathcal{F}\mathcal{O}}\ \left[\eta_{\mathcal{O}\mathcal{F}}\ \ (m_{\mathcal{F}}-\tau_{\mathcal{F}})-\left(\frac{W_{\mathcal{O}}}{W_{\mathcal{F}}}\right)(1+\tau_{\mathcal{O}})\right]}{(\eta_{\mathcal{O}\mathcal{O}}-1)(\eta_{\mathcal{F}\mathcal{F}}-1)}$$

Appendix B. Derivation of Demand Price Elasticities

We first derive price elasticities at the store level and then we aggregate them over stores. The demand of product j at store s is $q_{js}=\sum_{\ell=1}^{L}H_{\ell}\ \mathbb{P}_{\ell s}\ \mathbb{P}_{g(j)|s}\ \mathbb{P}_{j|s,g(j)}$. Using the definition $H_s^*\equiv\sum_{\ell=1}^{L}H_{\ell}\ \mathbb{P}_{\ell s}$ as the total number of consumers visiting store s, we can write this demand as

$$q_{js}=H_s^*\ \mathbb{P}_{g(j)|s}\mathbb{P}_{j|s,g(j)}$$

such that:

$$\begin{aligned}\frac{\partial q_{js}}{\partial p_k} &= H_s^*\ \mathbb{P}_{g(j)|s}\ \frac{\partial\mathbb{P}_{j|s,g(j)}}{\partial p_k}+H_s^*\ \frac{\partial\mathbb{P}_{g(j)|s}}{\partial p_k}\mathbb{P}_{j|s,g(j)}+\frac{\partial H_s^*}{\partial p_k}\mathbb{P}_{g(j)|s}\ \mathbb{P}_{j|s,g(j)}\\ &= q_{js}\left[\frac{\partial\mathbb{P}_{j|s,g(j)}}{\partial p_k}\frac{1}{\mathbb{P}_{j|s,g(j)}}+\frac{\partial\mathbb{P}_{g(j)|s}}{\partial p_k}\frac{1}{\mathbb{P}_{g(j)|s}}+\frac{\partial H_s^*}{\partial p_k}\frac{1}{H_s^*}\right]\end{aligned}$$

Probability $\mathbb{P}_{j|s,g(j)}$ has the logit structure $\mathbb{P}_{j|s,g(j)}=\frac{a_{js}\ \exp\{\delta_j/\sigma_1\}}{\sum_{k\in g(j)}a_{ks}\ \exp\{\delta_k/\sigma_1\}}$ with $\delta_k=X_k\ \beta_x-\alpha\ p_k+\xi_k$, such that:

$$\frac{\partial\mathbb{P}_{j|s,g(j)}}{\partial p_k}\frac{1}{\mathbb{P}_{j|s,g(j)}}=\begin{cases}-\dfrac{\alpha}{\sigma_1}\left[1-\mathbb{P}_{j|s,g(j)}\right] & \text{if} \quad k=j\\ \dfrac{\alpha}{\sigma_1}\ \mathbb{P}_{k|s,g(j)} & \text{if} \quad k\neq j \text{ and } k\in g(j)\\ 0 & \text{if} \quad k\notin g(j)\end{cases}$$

Probability $\mathbb{P}_{g(j)|s}$ has also a logit structure $\frac{\exp\left\{(\sigma_1/\sigma_2)\ I_{gs}^{(1)}\right\}}{\sum_{g'=1}^{G}\exp\left\{(\sigma_1/\sigma_2)\ I_{g's}^{(1)}\right\}}$ with $I_{gs}^{(1)} = \ln\left(\sum_{j\in g} a_{js}\ \exp\left\{\frac{\delta_j}{\sigma_1}\right\}\right)$. Therefore,

$$\frac{\partial \mathbb{P}_{g(j)|s}}{\partial p_k}\frac{1}{\mathbb{P}_{g(j)|s}} = \begin{cases} -\dfrac{\alpha}{\sigma_1}\dfrac{\sigma_1}{\sigma_2}\mathbb{P}_{k|s,g(k)} + \dfrac{\alpha}{\sigma_1}\dfrac{\sigma_1}{\sigma_2}\mathbb{P}_{k|s,g(k)}\ \mathbb{P}_{g(k)|s} & \text{if} \quad k\in g(j) \\ \dfrac{\alpha}{\sigma_1}\dfrac{\sigma_1}{\sigma_2}\mathbb{P}_{k|s,g(k)}\ \mathbb{P}_{g(k)|s} & \text{if} \quad k\notin g(j) \end{cases}$$

And probability $\mathbb{P}_{\ell s}$ has also the logit structure $\mathbb{P}_{\ell s} = \frac{\exp\left\{(\sigma_2/\sigma_3)\ I_s^{(2)}+\gamma\ d_{\ell s}\right\}}{1+\sum_{s'\in R(\ell)}\exp\left\{(\sigma_2/\sigma_3)\ I_{s'}^{(2)}+\gamma\ d_{\ell s'}\right\}}$, with $I_s^{(2)} = \ln\left(\sum_{g=1}^{G}\exp\left\{(\sigma_1/\sigma_2)\ I_{gs}^{(1)}\right\}\right)$. Therefore,

$$\frac{\partial \mathbb{P}_{\ell s}}{\partial p_k} = -\frac{\alpha}{\sigma_1}\frac{\sigma_1}{\sigma_2}\frac{\sigma_2}{\sigma_3}\ \mathbb{P}_{\ell s}\left[\mathbb{P}_{k|s,g(k)}\ \mathbb{P}_{g(k)|s} - \textstyle\sum_{s'\in R(\ell)}\mathbb{P}_{\ell s'}\ \mathbb{P}_{k|s',g(k)}\ \mathbb{P}_{g(k)|s'}\right]$$

And taking into account that $\partial H_s^*/\partial p_k = \sum_{\ell=1}^{L} H_\ell\ \partial\mathbb{P}_{\ell s}/\partial p_k$, we have that:

$$\frac{\partial H_s^*}{\partial p_k}\frac{1}{H_s^*} = -\frac{\alpha}{\sigma_1}\frac{\sigma_1}{\sigma_2}\frac{\sigma_2}{\sigma_3}\ \mathbb{P}_{k|s,g(k)}\ \mathbb{P}_{g(k)|s}\ \left[1-\psi_{sk}\right]$$

with

$$\psi_{sk} \equiv \frac{\sum_{\ell=1}^{L} H_\ell\ \mathbb{P}_{\ell s}\left[\sum_{s'\in R(\ell)}\mathbb{P}_{\ell s'}\ \mathbb{P}_{k|s',g(k)}\ \mathbb{P}_{g(k)|s'}\right]}{\sum_{\ell=1}^{L} H_\ell\ \mathbb{P}_{\ell s}}$$

Note that, if all the stores have the same assortment of products, then the term $\dfrac{\partial H_s^*}{\partial p_k}\dfrac{1}{H_s^*}$ is equal to zero. When all the stores have the same assortment, we have that the probabilities $\mathbb{P}_{k|s,g(k)}$ and $\mathbb{P}_{g(k)|s}$ are the same for every store s, i.e., $\mathbb{P}_{k|s,g(k)} = \mathbb{P}_{k|g(k)}$ and $\mathbb{P}_{g(k)|s} = \mathbb{P}_{g(k)}$ for every s. This implies that $\psi_{sk} = 1$, therefore $\dfrac{\partial H_s^*}{\partial p_k}\dfrac{1}{H_s^*} = 0$. In other words, a change in prices has an effect of consumers' choice of store only if some have a different product assortment.

Combining these expressions, we have that:

$$\frac{\partial q_{js}}{\partial p_k} = \begin{cases} q_{js}\left(-\dfrac{\alpha}{\sigma_1}\right)\left[1-\mathbb{P}_{j|s,g(j)}\left[1-\dfrac{\sigma_1}{\sigma_2}\left[1-\mathbb{P}_{g(j)|s}\left[1-\dfrac{\sigma_2}{\sigma_3}\left(1-\psi_{sj}\right)\right]\right]\right]\right] & \text{if} \quad k=j \\ q_{js}\left(\dfrac{\alpha}{\sigma_1}\right)\ \mathbb{P}_{k|s,g(k)}\left[1-\dfrac{\sigma_1}{\sigma_2}\left[1-\mathbb{P}_{g(k)|s}\left[1-\dfrac{\sigma_2}{\sigma_3}\left(1-\psi_{sk}\right)\right]\right]\right] & \text{if} \quad k\neq j \text{ and } k\in g(j) \\ q_{js}\left(\dfrac{\alpha}{\sigma_1}\right)\ \mathbb{P}_{k|s,g(k)}\ \mathbb{P}_{g(k)|s}\left[1-\dfrac{\sigma_2}{\sigma_3}\left(1-\psi_{sk}\right)\right] & \text{if} \quad k\notin g(j) \end{cases}$$

And the price-demand elasticities at the store level, $\eta_{jk}^s = (\partial q_{js}/\partial p_k)\ (p_k/q_{js})$,

$$\eta_{jk}^s = \begin{cases} p_j\left(-\dfrac{\alpha}{\sigma_1}\right)\left[1-\mathbb{P}_{j|s,g(j)}\left[1-\dfrac{\sigma_1}{\sigma_2}\left[1-\mathbb{P}_{g(j)|s}\left[1-\dfrac{\sigma_2}{\sigma_3}\left(1-\psi_{sj}\right)\right]\right]\right]\right] & \text{if} \quad k=j \\ p_k\left(\dfrac{\alpha}{\sigma_1}\right)\ \mathbb{P}_{k|s,g(k)}\left[1-\dfrac{\sigma_1}{\sigma_2}\left[1-\mathbb{P}_{g(k)|s}\left[1-\dfrac{\sigma_2}{\sigma_3}\left(1-\psi_{sk}\right)\right]\right]\right] & \text{if} \quad k\neq j \text{ and } k\in g(j) \\ p_k\left(\dfrac{\alpha}{\sigma_1}\right)\ \mathbb{P}_{k|s,g(k)}\ \mathbb{P}_{g(k)|s}\left[1-\dfrac{\sigma_2}{\sigma_3}\left(1-\psi_{sk}\right)\right] & \text{if} \quad k\notin g(j) \end{cases}$$

Finally, given the aggregate demand $q_j = \sum_{s=1}^{S} q_{js}$, we have that $\partial q_j/\partial p_k = \sum_{s=1}^{S} \partial q_{js}/\partial p_k$, such that the aggregate demand price elasticities are just weighted averages of store-level elasticities:

$$\eta_{jk} = \left(\sum_{s=1}^{S} \frac{\partial q_{js}}{\partial p_k} \right) \frac{p_k}{q_j} = \sum_{s=1}^{S} \eta_{jk}^{s} \left(\frac{q_{js}}{q_j} \right)$$

Appendix C. Algorithm for construction of submarkets.

We construct submarkets using an iterative algorithm. The partition of stores into submarkets can be described using a matrix $\mathbf{B} = \{b_{sm}\}$ of $0's$ and $1's$ such that each row represents a store, each column represents a submarket, element b_{sm} is equal to 1 if store s belongs to submarket m, and $b_{sm} = 0$ otherwise. Since we have a partition, every row of this matrix contains only one 1 and the rest of the elements are zero.

We start the algorithm with a matrix $\mathbf{B}^{(0)}$ with zeroes everywhere. First, we construct submarket 1 that corresponds to the first column of matrix $\mathbf{B}$. Let $\mathbf{b}_1$ represent column 1 of matrix $\mathbf{B}$. We initialize the algorithm with a vector $\mathbf{b}_1^{(0)}$ with zeroes everywhere expect at position $(1,1)$ where element $b_{11}^{(0)}$ is equal to 1. That is, without loss of generality, store 1 belongs to submarket 1. We also create a set of consumer locations $\mathcal{L}_1$ equal to the set $C^{-1}(1)$. In the first iteration, we update the elements of the vector $\mathbf{b}_1^{(0)}$ to obtain a new vector $\mathbf{b}_1^{(1)}$. The updating proceeds as follows. Consider store $s = 2$. If the sets $\mathcal{L}_1$ and $C^{-1}(2)$ have elements in common, then we make element $b_{21}^{(1)} = 1$ and update $\mathcal{L}_1$ to the union of the previous set $\mathcal{L}_1$ and the set $C^{-1}(2)$, i.e., $\mathcal{L}_1 := \mathcal{L}_1 \cup C^{-1}(2)$. Otherwise, for the moment we keep $b_{21}^{(1)} = 0$ and the set $\mathcal{L}_1$ is not changed. Then, we consider store $s = 3$. If $C^{-1}(3)$ has elements in common with $\mathcal{L}_1$, then we make $b_{31}^{(1)} = 0$ and update $\mathcal{L}_1 := \mathcal{L}_1 \cup C^{-1}(3)$. Otherwise, we keep $b_{31}^{(1)} = 0$ and do not modify the set $\mathcal{L}_1$. We proceed in the same way over all the S stores to obtain a new vector $\mathbf{b}_1^{(1)}$ at the end of this round/iteration. If $\mathbf{b}_1^{(1)} = \mathbf{b}_1^{(0)}$, then we conclude that vector $\mathbf{b}_1^{(1)}$ describes submarket 1, and then we proceed with submarket 2. Otherwise, if $\mathbf{b}_1^{(1)} \neq \mathbf{b}_1^{(0)}$, we need to consider an additional iteration to update the vector to $\mathbf{b}_1^{(2)}$. We keep iterating until $\mathbf{b}_1^{(k+1)} = \mathbf{b}_1^{(k)}$.

To obtain the rest of the submarkets, we operate in a similar way. Suppose that we have already created submarkets 1, 2, ..., m, such that we have the vectors $\mathbf{b}_1$, $\mathbf{b}_2$, ..., $\mathbf{b}_m$. If matrix $[\mathbf{b}_1$, $\mathbf{b}_2$, ..., $\mathbf{b}_m]$ has a 1 at every row, then we can conclude that there is a total of m submarkets and matrix $\mathbf{B}$ is equal to $[\mathbf{b}_1$, $\mathbf{b}_2$, ..., $\mathbf{b}_m]$. Otherwise, that is, if some stores have not been assigned yet to a submarket, we proceed with submarket $m + 1$. We start with a column vector $\mathbf{b}_{m+1}^{(0)}$ with zeroes everywhere except at some position, say j, where $b_{j,m+1} = 1$. Note that position j should be such that store j does not belong to submarkets 1 to m, i.e., $b_{j1} + b_{j2} + ... + b_{jm} = 0$. Then, we update $\mathbf{b}_{m+1}^{(0)}$ to $\mathbf{b}_{m+1}^{(1)}$ using the same procedure as the one described above for submarket 1, and we iterate in this procedure until $\mathbf{b}_{m+1}^{(k+1)} = \mathbf{b}_{m+1}^{(k)}$.

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